Notebook, N-88-06-06

This notebook, which covers the period June-July 1888, is a continuation of N-88-04-18. It contains transcriptions by Arthur E. Kennelly of material from the rough record books used by experimenters in the Galvanometer Room. There are notes, drawings, and calculations regarding armature windings and dynamos, including multipolar and municipal dynamos and a plating dynamo; batteries; non-magnetic watches; and the "new Edison voltmeter." There are also notes on electrocution experiments, the electric light system at Llewellyn Park, and the calibration of instruments, along with calculations on the cost of procuring zinc sulphate. Among the experimenters whose work appears in this book are F. P. Bergh, Arthur E. Colgate, Johannes H. Cuntz, and Oren S. Hussey. Attached to the inside back cover is an index. The front cover is labeled "Record Book No. 3. Galvanometer Room." The back cover is labeled "512." The spine is labeled "48." The book contains 88 numbered pages followed by 8 unnumbered pages. Some pages were removed before the book was paginated. Numerous graphs have been pasted into the book.

The index has been filmed first.

Armatures – 47
Ammeters – 52 – 39
Accumulators – 13-23-25
Converter – 9
Dynamo – 53-54-55
Dynamo Plating – 72. 73
" Multipolar – 1. 2. 3. 4. 5. 6. 15. 16. 17. 18. 19.
" Municipal – 10-11. 12. 13. 14.
Edison Voltmeter – 69. 81.
" System – 19. 25. 27.
Glass tubes – 61
Electrometer – 82 – 88
H – 44. 111. 112. 113. 63. 64. 65. 66. 67. 68.
Leads Engine room – 61
Meter Plates – 45. 50. 61. 62
Mason Cells – 69. 76. 84. 91. 92.
Physiological – 71. 72. 74. 75. 78. 79. 80. 85. 86. 87
Pendulum – 7. 58. 60. 69. 71. 76. 77. 83.
Permeability – 20. 21. 22. 26. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37
Phonograph Motor – 48. 46
Phonograph Motor – 49-50.
Roberts Cells – 23. 24-44-49. 69-70-84-85-89-90-91
Standard Cells – 19. 28
Voltmeter – 51
[illegible] – 45. 48. 51. 56. 57.
[illegible] Sulphate – 8. 59.

x E-172

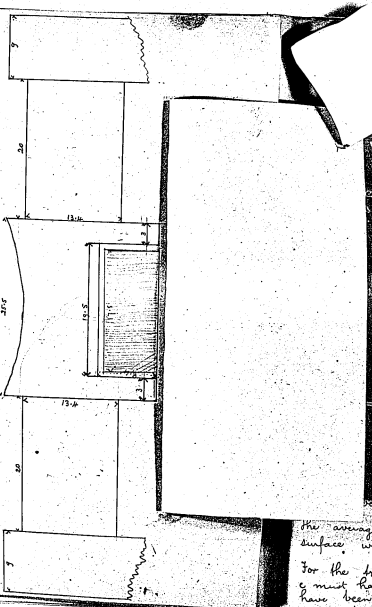
N-88-06-06

Record Book
of observations
in the
Galvanometer Building
Edison Laboratory

Commenced 6th June 1888
Concluded

No 3.

Radial Section through axes of a pair of magnet cores in the Edison Multipolar Dynamo, lengths in cm:



with

dynamo.

of layers on each magnet
total at 25 and there being
18·5 turns to the layer the
number of active turns is 3875

formula for a double horseshoe
on page 109 converted into C G S. U

$$\frac{2.54\,P \times 1.6 \times 6000}{\frac{3600\,d}{D} + \frac{2\,l}{a} + \frac{3\,s}{d}}$$

corresponding force in this case	2X3875c
dyne-hours - - - -	1
turns-passing surface - - -	390
length of mean armature curve, here	78
cm - - - -	112·5
length - - magnet - -	60
cm - - - - -	1420

$$\frac{2 \times 3875 \times \frac{1}{2.54} \times 1.6 \times 6000\,c}{\frac{3600}{390} + \frac{78}{112.5} + \frac{180}{1420}}$$

2.1×10^6 for value of z

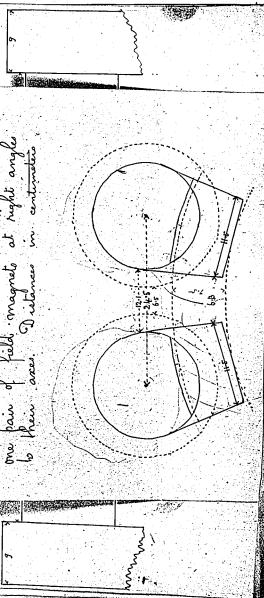
Numerical Evaluation.

the average field for the 135 gems of ring surface would be $\frac{2.54}{1.35} \times 10^8 c = 2.0 \times 10^8 \times c$.

For the trial on page 79 book 2 the current must have been 0·11 and the field should have been 2.2×10^3 or $\frac{22}{10}$ Gauss. It was reckoned at $\frac{22}{19}$ or 33·4 c. shunt.

Radial Section through axes of a pair of magnet cores

Section of Edison Multiplex Dynamo through one pair of field magnets at right angles to their axes. Distances in centimetres



(C)

Data connected with the Multiplex Dynamo

The number of layers on each magnet coil being stated at 25 and there being about 155 turns to the layer the total number of active turns is 3875

Happy's formula for a double horseshoe magnet of each iron on page 109 converted into C G S. U.

$$Z = \frac{2.54\,P \times 1.6 \times 6000}{\frac{3600\,d}{S} + \frac{2\,l}{a} + \frac{3\,L}{A}}$$

where P is magnetizing force in this case 2X3875c

d	clearance	1
S	lines passing surface	390
l	length of mean armature curve here	18
a	area	112.5
L	length of magnet	60
A	area	1430

$$Z = \frac{2 \times 3875 \times \frac{1}{2.54} \times 1.6 \times 6000\,c}{\frac{3600}{390} + \frac{18}{112.5} + \frac{180}{1430}}$$

$$= 2.5\,c \times 10^6$$ for value of z well below saturation.

The average field for the 135 gems of ring surface would be $\frac{2.5}{1.35} \times 10^5 c = 2.0 \times 10^5 \times c$

For the trial on page 79 book 2 the current c must have been 0.11 and the field should have been 1.2×10^3 or 12 Gauss. It was reckoned at 49 or 33 % short.

Taking the same calculation in Kapps method.

$$Z = \frac{1.6 \times 7750 \times c}{\frac{1800 \times 0.79}{60} + \frac{14}{18} + \frac{75}{22}}$$

$$= \frac{12400\,c}{23.7 + 0.8 + 3.4}$$

$$= \frac{12400\,c}{28} = 443\,c$$

$$\therefore = 443 \times 6000\,c = 2658000\,c = 2.7 \times 10^6\,c$$

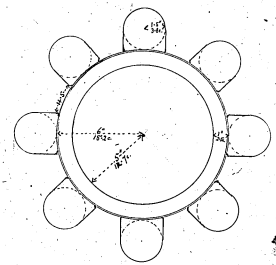
To saturate the cast iron cores would probably require about 10,000 ℓ per sq. cm. and there are 143 sq. cm so that 1,430,000 would be required $= 1.43 \times 10^6$

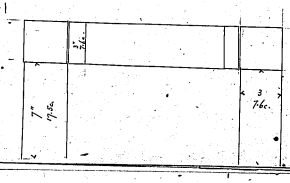
$$\therefore c = \frac{1.43}{2.7} = 0.53 \text{ or } 5.3 \text{ amperes.}$$

If 9000 lines would saturate $c = 4.8$ ampere

(2)

To determine the winding of a transformer ring whose diameter is 12" external running at a circumferential speed of 1200 ft per sec. there being 4 magnet in series (8 coils), the pressure being 1100 volts and the external P.D. 112 volts.





1st Required the winding to bring the core up to 90% of saturation. Say to 8000 lines per sq. cm.
The area being 45.4 sq. cm. 363,200 lines will be required. Here by Hopkinson's formula

$$Z = \frac{0.8\,P \times \frac{6000}{2.54}}{\frac{3600\,d}{S} + \frac{l}{a} + \frac{3\,C}{A}}$$

where $d = \frac{1}{8}$" $= 0.32$ c. — 0.125"
$S = 57.76$ sq. cm. — 9.0 sq. in.
$l = 120$ cms. — 5 in.
$a = 19$ sq. cm. — 3 sq. in.
$C = 50$ — 20.
$A = 45.4$ — 7.1

$$Z = \frac{0.8\,P \times 2{,}360}{\frac{3600 \times}{17.3} + \frac{12}{19} + \frac{150}{45.4}}$$

$$= \frac{1{,}885\,P}{20.8 + 0.63 + 3.3} = \frac{1888P}{24.73} = 76.34P$$

$$\therefore P = \frac{363200}{76.34} = 4760$$

Checking the calculation in Inches

$$Z = \frac{0.8\,P \times 6000}{\frac{3600 \times .0250}{9} + \frac{5}{3} + \frac{60}{7.1}}$$

$$= \frac{4800P}{80 + 1.7 + 8.4} = \frac{4800P}{90} = 53.3\,P$$

$$P = \frac{363200}{80} = 4500$$ practically the same

Thursday 7th June.

Took following set of Characteristic observations on Multiplex Dynamo running at slower speed to see if the speed of revolution visibly interfered with the saturation point.
The observations are plotted on page 89 book 2.

Time	Speed Observed Revs/min	Assumed Speed Revs/min	Current in Volts act.	Current in each coil	Volts by Voltmeter	Volts by A.H.	Volts reduced to 350 revs	Volts reduced to 800 revs
9.5.	348	348	16.0	0.67	36	33	33.2	75.9
	~~348~~	348	20	0.83	36	34.2	36.4	83.2
		348	24	1.00	38	39	39.2	89.6
		347	26	1.08	40	41	41.35	94.52
		346	30	1.25	43	43	43.95	99.44
		345	31	1.29	44	43.5	44.0	100.6
	340	344	33	1.375	45	45	45.8	104.7
		343	35	1.46	45	46	46.95	107.4
		343	38	1.58	46	47	47.96	109.7
		342	40	1.675	46.5	47	48.8	111.56
		342	44	1.83	47	49.0	50.15	114.6
		341	46	1.92	49	50.0	51.3	117.3
		341	50	2.08	50.5	52.0	53.37	122.0
		340	52	2.17	51	52.5	54.02	123.4
		340	55	2.29	52	53.0	54.56	124.7
		339	56	2.33	52.2	53.5	55.24	126.3
		339	58	2.42	52.5	54.0	55.76	127.5
		338	60	2.50	53.5	54.5	56.43	129.0
		338	61.5	2.56	54	55.2	57.15	130.6
		337	64.5	2.69	54.2	55.7	57.85	132.2
		337	66.5	2.77	55.5	56	58.15	132.9
		336	68	2.83	55.5	56.5	58.85	134.5
		335	69	2.88	55.7	57	59.55	136.1
		334	70	2.92	55.9	57.2	59.93	137.0
9.25.	334	334	71	2.96	56	57.5	60.25	137.7

(7) $$Z_{mw} = \frac{118\,\mathfrak{A}}{\frac{1440\,d}{S} + \frac{l}{a} + \frac{2\,l}{A}}$$ multipolar magnet wrought iron + cast iron poles.

(8) $$Z_{mc} = \frac{94\,\mathfrak{A}}{\frac{1800\,d}{S} + \frac{l}{a} + \frac{3\,l}{A}}$$ multipolar magnet cast iron

d = clearance (centrifu)
S = Magnetic surface
l = mean mag. dist: this armature.
a = mean area of armature (magnetic)
L = mean mag. dist. this magnet
a = mean area of magnet
$\mathfrak{A}$ = ampere turns

Allowing 4700 as the exciting power of each pair of coils; then $\frac{23500}{c}$ will be the number of turns on each limb if c be the current in amperes.

The Kapp formula applicable strictly speaking to Gramme armatures and fields of 10,000 lines to the sq cm or less, only are, reduced to cm. measurement :—

(1) $$Z_w = \frac{118\,\mathfrak{A}}{\frac{1440\,d}{S} + \frac{l}{a} + \frac{l}{A}}$$ (in wrought iron) of armature with cast iron pole

(2) $$Z_c = \frac{94\,\mathfrak{A}}{\frac{1800\,d}{S} + \frac{l}{a} + \frac{1.5\,l}{A}}$$ (in cast iron) magnet

(3) $Z_{mw} = 2\,Z_w$ nearly or

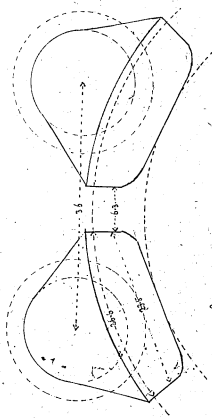
$$\frac{236\,\mathfrak{A}}{\frac{1440\,d}{S} + \frac{2l}{a} + \frac{2l}{A}}$$ (double magnets) in wrought iron with cast iron poles

(4) $$Z_{mc} = \frac{188\,\mathfrak{A}}{\frac{1800\,d}{S} + \frac{2l}{a} + \frac{1.5\,l}{A}}$$ (double magnets) in cast iron magnet

(5) $$Z_{mw} = \frac{236\,\mathfrak{A}}{\frac{1440\,d}{S} + \frac{2l}{a} + \frac{2l}{A}}$$ (double multipolar magnets) wrought iron cores + cast iron poles

$$= \frac{118\,\mathfrak{A}}{\frac{720\,d}{S} + \frac{l}{a} + \frac{l}{A}}$$

(6) $$Z_{mc} = \frac{188\,\mathfrak{A}}{\frac{1800\,d}{S} + \frac{2l}{a} + \frac{3\,l}{A}}$$ (double multipolar magnets) cast iron.



Projected Bipolar Dynamo.
½ Scale. Measured in Ohms.

Casting the Multipolar Dynamo afresh with 8 magnets instead of 12, we have the following diagram and calculations.

$d = 1$

$S = 26.6 \times 17.8 + 23 \times 7.5 = 473.5 + 172 = 645$

$l = 33$ (mean path)

$a = 112$

$\mathcal{L} = 80$

$\mathcal{A} = 143$ $\qquad \mathfrak{A} = 7600$ c.

Whence $Z = \dfrac{188 \times 7600\,c}{\dfrac{1800}{645} + \dfrac{66}{112} + \dfrac{240}{143}}$

$= \dfrac{1429000\,c}{2.8 + 1.2 + 1.7}$

$= \dfrac{1429000\,c}{5.7} = 3.4\,3\,7,000\,c$

10,000 lines to ap. cm. makes $Z = 1,430,000$

whence $= c = \dfrac{1430}{3.4\,3\,7} = 4.1$

and the gain in EMF is in ratio of 2.7 to 3.5 or nearly 30%.

The Pendulum Electro magnet
is made up as follows:—
The cores are 40·5 cms long and have
an average area of 46·57 cm.
so that the length of core is 81 @ 46·57
The yoke is a rectangular bar 7.4 × 7.4.
and the distance between the
core centres is 32·75 so that
if the poles were in direct connection
the length of yoke would be 65·5 @ 54·75
and at any time the mean distance of yoke
is (65·5 − d) at 54·75 area.

Assume the magnetic resistance of air
as $\frac{1}{4\pi}$ and let x be the magn: res: of the
iron. Then at 2·5 cms. I.P.D. the res: of
the air space may be regarded as 9(d)
while the res: of the remainder of the
circuit is $\frac{63}{54.75}x + \frac{81x}{46.57} = x(1.15 + 1.74) = 2.9x$ approx

The total number of lines formed at that time
was with 1905 ampere turns $2863 \times 46.57 = 133,330$
The wire being wound on a distance of 38·65 cms
and there being 1905 turns makes a mean
no of 4·929 turns per cm. the magnetic
field should therefore be approx. $\frac{4\pi}{10} \times 4.929$.
$= 61.94$
By Kapp's formula we would, have

$$I = \frac{119 \times 1905}{\frac{14400 \times 2.5}{46.57} + 2.9} = \frac{224,790}{10.6} = 21,200$$

Friday 8th June.

Two plates of zinc 28 × 29·1 or 819 sq. cms. and 0·0381 cm thick 1 sq ft 5 or 192·5 sq cms were immersed to about 46 sq. cms in Zn Sol. solution, this was composed of 5900 grammes of commercial zinc sulphate in 41,600 grammes of water. The current from the 110 volt Dynamo was passed through 2 lamp banks (16 16 lamps) at 114·50 giving 27 ampères.

1 ampère to 17 sq. cms.

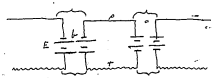
1 Gr. deposits 0·0001038 gr. H.
or 32·5 × 0·0001038 - Zn
= 0·00339 -
1 Coulomb - = 0·000339 - = 3·39 × 10^{-6}
3600 - - = 12·20 - Zn
4553·6 ampère hours = 370·0 1 lb. of Zn.
12·20
says 370. ampère hours per lb of Zn

∴ $\frac{370}{27}$ = 13·7 hours current for this current per lb.

1 Ampère hour gives 1·22 gr. Zn
$\frac{1000}{1.22}$ or 819·6 ampère hours give 1000 gr. Zn
at rate of 27 ampère 30 hours give 1000 -
- or 1 - - 33 - approx.

At 16.30 57 grammes had been deposited
= 1·8 ampères ought by calculation to have been 27

Added 4 more plates reducing the density of current to one fifth or 1 ampère to 85 sq cms
All set to work at 16.40



$$c = \frac{2E}{2b + r + p}$$

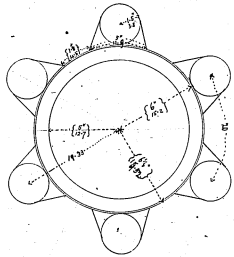
$$\mathcal{L}_c = \frac{236\,aJ}{\frac{1440\,d}{\frac{S}{2}} + \frac{l}{a} + \frac{l}{\frac{A}{2}}}$$

$$= \frac{118\,aJ}{\frac{1440\,d}{S} + \frac{l}{a} + \frac{l}{a}}$$

$$\mathcal{L}_c = \frac{94\,aJ}{\frac{1800\,d}{S} + \frac{l}{a} + \frac{1.5\,\mathcal{L}}{A}}$$

(4)

Required the exciting power for a converter similar to that on page 2 but a sexipolar instead of an octopolar machine



$d = \frac{1}{8}'' = 0.32$ cms.

$S = 144.0$ sq. in $= 11.9 \times 7.6 = 90.4$ sq. cms

$l = 4.5 + \frac{11.9}{4} = 7.5$

$a = 19$

$\mathcal{L} = 55$ cms

$A = \bigcirc = 22.7$ sq. cms.

$$363{,}000 = \frac{94\,aJ}{\frac{1800 \times 0.32}{90.4} + \frac{3.75}{19} + \frac{825}{45.4}}$$

$$= \frac{94\,aJ}{6.37 + 0.20 + 1.8} = \frac{94\,aJ}{8.37} = 11.2\,aJ.$$

$$\therefore aJ = \frac{363{,}000}{11.2} = 32{,}400 = 16{,}200 \text{ on each limb.}$$

The Edison no 2 Municipal has magnetos offering 1200 v, and presumably carrying $\frac{1000}{1200}$ or 0.77 ampères. The diameter of the wire is 0.028" and offers 0.01317 v per foot.
The energy consumed in heating this wire is 1000 × 0.77 or 770 Watts = $\frac{770}{4.2}$ = 183 g. cal per sec.
The radiating surface on these coils is 13⅝ × π × 20¾ × 6.45 sq. cms. = 57,200 so that there are $\frac{57200}{183}$ or 313 sq. cms. of radiating surface per g. cal per sec.

If now 1 ampère be employed in exciting the machine, the EMF in each of the 12 coils will be $\frac{110}{12}$ or 9.167 volts and the energy expended in heating each coil is 9.167 Watts or 2.183 g. cal. per sec. the radiating surface will be on one of these coils about 17.5 × 12.5 × 3.14 sq. cms. 687.5 sq. cms or $\frac{687.5}{2.183}$ = 315 nearly 10 times as much heat as in the Edison No 2.
Allowing 2.5 times as much heat as in the No 2. or $\frac{313}{2.5}$ = 125 sq. cms. per g. cal. the HF must be $\frac{687.5}{125}$ = 5.5 or 5.5 × 4.2 Watts = 23.1 Watts
$\frac{23.1}{9.167}$ = 0.25 or ¼ of an ampère. To carry this current allowing 200 c.m. to the ampère = 75 c.m. or need only be 0.009" no 32 B.W.G. but as that would be too expensive dry) No 26 0.018" in diam. might be used. To carry 0.25 ampère at 9.167 volts one must have 366.8 v or 366.8 × 31.39 feet = 11500 feet. Taking the mean turn at 12" or 1 foot would mean 11,510 turns or 2,880 Ampère turns only about one fifth of our desired magnetisation If No. 30 wire were adopted the diam. being 0.012, the length to be used would be less and – the at least Using no 23 wire whose diam = 0.025 the length would be 366.8 × 60.54 = 22,200 feet and the A.T would be (1 layer 200 turns = say 350 feet = 66 layers or 5.7" magnetizing turns) 18,600 = say

Rule: To find the no: of layers on a magnet core having given the winding space dimensions the length of the wire and its diameter.

Let L = the length of wire
d = its diameter (covered)
D = diameter of the ~~spool~~ core
t = the no of turns in a layer
l = the required no: of layers

Then

$$l = \frac{\sqrt{D^2 + \frac{4Ld}{\pi t}} - D}{2d}$$

The number of turns will be with no 23 wire as follows. Drum of 1st layer say 3.25". There will be .7 × 40 or 280 turns in each layer.

Let l = the no. of layers.
" t = " " turns in a layer
" D = " diameter of the 1st layer (bare)
" d " " " " wire covered.

Then $D + 2ld$ will be the external diameter. The mean diameter will be $D + ld$ and the total length L of wire will be

$$L = lt\pi(D + ld)$$

Here l is the unknown quantity.

$$l^2(t\pi d) + l(t\pi D) = L$$

$$\text{or } l^2 + l\frac{D}{d} = \frac{L}{t\pi d}$$

$$\therefore l^2 + l\frac{D}{d} + \left(\frac{D}{2d}\right)^2 = \frac{4Ld + D^2 t\pi}{4t\pi d^2}$$

$$\therefore l + \frac{D}{2d} = \pm\frac{\sqrt{D^2 t\pi + 4Ld}}{2d\sqrt{t\pi}}$$

$$l = \frac{\pm\sqrt{\frac{D^2 t\pi + 4Ld}{t\pi}} - D}{2d} = \frac{\pm\sqrt{D^2 + \frac{4Ld}{t\pi}} - D}{2d}$$

Here L = 22,200 × 12 = 266,400 inches
D = 3.25
d = say 0.028
t = 240 allowing covered diam = 0.028". 6 to" spaci.

$$\therefore l = \frac{\pm\sqrt{\left\{(3.25)^2 + \frac{0.112 \times 266{,}400}{240 \times 3.142}\right\}} - 3.25}{0.056}$$

$$\frac{\sqrt{10.56 + 29.57}}{0.056} = \sqrt{10.13} = 7.08$$

$$\frac{10.56 + 29.930}{7.53.8} = \frac{29.8400}{7.526} = 39.58$$

$$\sqrt{39.58} = 7.08 - 3.25 = 3.83 \div 0.056 = 68.$$

Mean Diam = 3.25 + 68 × 0.028 = 5.15" × π t = 5.15 × 749 = 3.83 × 68.

If only 6 magnet coils are used, and the heating is not excessive, the same winding might be employed and 0·5 ampere used. The ampere turns would then be $68 \times 240 \times 0{\cdot}5 = 16320 \times 0{\cdot}5 = 8{,}160$.

The Energy consumed in the coils will then be $11{\cdot}00 \times 0{\cdot}5 = 550$ Watts. about $\frac{6}{10}$ H.P.

Taking 8100 A T on each limb we have just 181,500 lines of force impressed on the wire of the armature by page 9 neglecting leakage.

The linear velocity of the armature at the circumference being $120 \times 30{\cdot}5$ cms per sec. $= 3660$ cms per sec: and the length of one turn being 7·6 cms. the area enclosed by the running wire is at the rate of 27,820 sq. cms. per sec:

The lines issuing from one pole are distributed over one sixth of the area of the ring rotation. That circum being $15{\cdot}2 \times 3{\cdot}14 = 47{\cdot}73 \times 7{\cdot}6 = 362{\cdot}8$ sq. cms. so that the average field of force is $6 \times \frac{181{,}500}{362{\cdot}5} = 3000{\cdot}$. The no: of lines enclosed per sec: by one turn of wire is thus $3000 \times 27{,}820 = 80{,}410{,}00 = \frac{100}{10^8}$ ~~$\frac{1}{10^8}$~~ to the volt.

The number to give 112 volts will be ~~124~~ $\times 112 =$ ~~13900~~ turns on each $\frac{1}{16}$th of the circumference say 1400 or 8400 ~~turns~~ altogether.

Infact into 3" 1400 turns have to be coiled.

Allowing ·50 ampere to be the output of the machine the armature at 150 ⊥ the amp. $= \frac{7500}{150}$ would be about no 20 wire 0·085" diam say covered 0·09" the would mean ~~to coil the~~ allowing in 15 layers of 75 turns

The length of wire would be approximately 100 feet on each segment and the res: of this would be 0·814 say 0·900 Rot or 0·150 for the internal res: of the armature. This would mean a loss of 50 × 50 × 0·15 = 375 Watts lost in heating the armature.

Set up an Electrical Accumulator Company's storage cell which arrived in the morning packed dry:—

It was composed of 15 leaden plates 23·5 × 25 cms. thus exposing 8,224 cq cms. on each plate multiplied. The whole 15 plates and attachment weighed 82lbs or 37,200 gms. On ~~pour~~ immersing them completely in dilute H_2SO_4 sp. grav. 1·150 the battery gave a current of 23 amperes through the small H&B ammeter + 15 through the large one. Kept it at work on 2·3 amperes from 10 o'clock.

The energy that has to be taken from the machine considered as a motor is 110 × 50 or 5500 Watts add to this the Watts in the dynamo and we have to provide for 5820 Watts add to this 10% for friction &c. and we have a total of 6500 Watts to be furnished by the motor. This must be the product of the EMF of ~~at the motor~~ and the current it conveys. Assuming that 1100 will be the E.M.F. then 5·9 amperes must be carried. Or from the equation $W = \left(\frac{E-e}{r}\right)e$ we have W being $6500 = \left(\frac{1100-e}{r}\right)e$ we are free to chose the terms e and r. $\therefore 6500r = 1100e - e^2$

$\therefore e^2 - 1100e = -6500r$

$\therefore e^2 - 1100e + 550^2 = -6500r + 302500$

$e^2 - 1100e = \sqrt{6500(47 + 46{\cdot}5)}$

$e - 550 = 81\sqrt{47+46{\cdot}5}$

$e = 550 + 81\sqrt{47+46{\cdot}5}$

Assuming t to be say 2.50 makes the armature radial part 7 and the counter e.m.f 1067 volts. Each segment would then offer a res: of 15 and the problem is to find a winding of 15 that shall offer an EMF of 1070 volts. at the rate of rotation above indicated. Each turn generates 0.8 volts so that there must be 1.24 X 1070 turns = 1327 Each turn is about 8' long or 0.67 feet and 1327 turns will be over 1327 X 0.67 say over 889 feet or 900 feet. This 900 feet must offer only 15 or 0.0167 per foot or no 23. wire. The diam: being 0.025" there is room for only 120 turns so that this wire is out of the question In fact allowing 3/8 of an inch for wire winding depth on the ring we know that $\frac{0.1}{d} \times \frac{3}{8}$ must exceed 1330. that is $d = \sqrt{\frac{0.3}{1330}} = \sqrt{0.00022556} = 0.015$.

that being our limit, we may take with greater safety the 0.013 wire no 29. whose res: is 0.061 ω per foot. Every turn of this wire introduces at least 0.061 X 0.67 ω and every volt 0.061 X 0.67 X 1.24 ω = 0.05024 ω. This however must be divided by 6 for the whole machine or 0.00837 ω for every volt. Now in the expression $\frac{e\,(E-e)}{r} = 6500$ we have

$$\frac{e\,(E-e)}{0.00837e} = 6500$$

or $E - e = 6500 \times 0.00837 = 54.42$ $\quad + r = 1045.6 \times 0.0083 = 8.75$

or $e = 1100 - 54.4 = 1045.6$ volts

The no: of turns must then be $1045.6 \times 1.24 = 1296$ say 1300. The dimensions of the mean turn will be $2(1.80 + 3.80) = 8.4'$ and the turns in a layer being 200 we have 1680' or 140 feet for the length of one layer. ~~The total length being 22.5 X 140 = 3150 feet.~~ We must then have 7 layers = 1400 turns and 980 feet. $7 \times 0.015 = 0.1'$. Res. $61 \div 6 = 10$ ω The current flowing will be assumed $\frac{54.44}{10} = 5.44$ amps or 0.44 amp in each segment

Revision of work as check:

Required the winding of the armature and field magnets of a converter working between 1100 and 112 volts at a circumferential velocity of 120 feet per sec: allowing 6 magnets and cores round the periphery of the armature whose ring shall be 10" and 12" int. + ext. diam. with ⅛" clearance, as a matter of necessity it will be an entefer of ⅞", the internal and external diameter being reduced by ⅛" to allow of bare winding. The machine is designed primarily to supply 50 amperes at a commercial output of 5600 Watts.

The magnet core will be wound with No 23 cotton-covered wire. 0.025" diam: commencing as close to the core as insulation will allow the diam of the first layer being taken as 3¼". There should be in the interflange of 6¾", 240 turns and 68 layers making 16,320 turns in all. The mean layer would have a diameter of 5.15" the outer diameter would be 6.95" or 7" and the total length of wire on each magnet would be 22,000 feet weighing 420 lbs. The total weight on the 6 cores would be 252 lbs: @ 76 c = $191.50

Each pair of cores will supply 8160 ampere turns at half an ampere of current because the res: of no 23 wire being 16.517 ω per 1000 ft the res: of each limb would be 22.2 × 16.517 = 366.7 ω and the 6 limbs together would offer 2200 ω or give 0.5 ampere to 1100 volts. The cir: mils of the wire being 625 allows 1250 cir: mils to the ampere and the radiating surface is 62.5 sq. cms. to the Heat Unit (gram Calorie) per sec: The energy expended in heating the coils will be (1100 × 500 Watts)

The ampere turns from any pair of cores being 16,320, we should expect from Hopkinson's formula modified to suit the multipolar machine a total induction of

$$\frac{94 \times 16{,}320}{\frac{1800\,d}{S} + \frac{l}{2a} + \frac{1.5L}{A}}$$

where d is the entrefer say 0.32 cm. (⅛")

S - - Inductive surface on the ~~half~~ polar-face or 90.4 sq. cms.

l - - 7.5 cms. of line dist. in armature

a - - area of induction in armature = 19.90

L - - Mean length the magnets = 55 cm

A - - - area - - = 45.4.

$$\therefore \text{Induction} = \frac{94 \times 16\,320}{6.37 + 0.2 + 1.8} = 181{,}500$$

= nearly 11,000 to the sq. cm.

This magnetisation has inductive influence over one sixth of the whole periphery of the armature or $\frac{30.4 \times 3.14 \times 7.6}{6} = 120.9$ sq. cms. so that the average field will be $\frac{181{,}500}{120.9}$ or 1,500 lines to the sq. cm.

The no. of lines enclosed per sec. by one turn of wire will be at the rate of $1500 \times 7.6 \times 120 \times 20.5 = 41.7 \times 10^6$ or the EMF from each turn will be $\frac{10^8}{10^8} \cdot \frac{41.7}{10^6} = 0.417$ volts. The number required to give one volt = 2.4 and for 112 volt 268.8 turns will be required on each segment of the armature say 270 or 1620 turns altogether in the secondary circuit. So that 270 turns must be wound within 3" allowing insulating space. Assuming that 50 amperes will be the output of the machine ~~the~~ and taking the circ. mil at 150 to the ampere we have

$\frac{50 \times 150}{6} = 1250$ as the circ. mils of each wire or no 20 wire 0.035" in diam say 0.04" insul. 75 turns of this would make a layer and 16 layers making 800 turns and a thickness of 0.16" = $\frac{1}{6}$" of wire if wound carefully. The length of this secondary wire would be approximately 214 feet and the res: of this at 0.00816 is 1.8ω cold or 2.0ω hot. The total res: of the machine would then be 0.23ω and the energy lost in heating the armature at full load would be $50 \times 50 \times 0.23 = 825$ Watts. The total length of secondary wire on the armature would be 1300 feet. The E.D. at full load $= 112 - 0.23 \times 50 = 95.5$ terminals during

The energy that has to be taken from the machine considered as a motor is 5500 Watts although only 4775 would be yielded externally on the above figures. Say that including the waste in the secondary circuit and the friction res: of the motor 6500 Watts must be absorbed by it then we know that

$$6500 = (1100 - e)\,e$$

Our limit of winding is such that $\frac{3}{d} \times \frac{0.16}{d} =$ No of turns in a segment.

Now if our efficiency is to be 85% a fair value then $e = 935$ say 940 volts and we must provide 2.4×940 or 2256 turns on each segment $\therefore \frac{0.48}{2256} = d = \sqrt{0.0002128} = 0.0146$ allowing for insulation say no 23 wire 0.013. The mean turn will be 8.6" and the No of turns in a layer will be 205 say 200 so that we shall have 12 layers or 2400 turns and a length on each segment of 1720 feet or 11,440 feet in all.

The resistance of this wire being. 0.0611 ω per foot will be 105.1 ω cold or say about 120 ω hot. So that the total res: in the primary cct. would be 20 ω. at normal speed therefore while giving a counter EMF of 950 volts the current flowing through the primary cct. would be $\frac{1100-950}{20} = \frac{150}{20} = 7.5$ amperes or 1.25 ampere through each ~~fire~~ segment. The circ. mils of the wire being 169 allows 135 circ. mils to the ampere, and if this is too great a current density the output must be reduced because at 1100 volts in order to consume 6500 Watts there must be a current of nearly 6 amperes without taking loss by conversion into account. Consequently the current flowing in each wire cannot be much below 1.25 amperes and if the circ: mils be increased the counter EMF will be reduced and a larger current will pass through.

Consequently we have at full load

Expended in Machine	Derived from Machine
In magnet coil	550 Watts
~~Heating~~ the primary cct	1120 "
Heating the secondary cct	825 "
Friction &c.	250 "
Delivery	~~5420~~ "
Total	8170

5420
~~70~~
66

$$\frac{2cr^2}{(r^2+x^2)^{\frac{3}{2}}} = H.$$

$$c = \frac{H\,(r^2+x^2)^{\frac{3}{2}}}{2r^2}$$

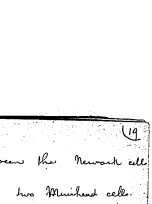
$$= 0.002644\,(x^2+36)^{\frac{3}{2}}$$

where c = current in abs. measure
r = radius ring
x = distance from centre.
H = horizontal component = 0.19.

Tested the 5 standard cells.
The greatest difference between the Newark cells is 0.0002 volt
The difference between the two Minehead cells is also about 0.0002 volt
The difference between the Newark + Minehead cells at the same temp: is less than 0.0005 volt

Test of Edison system 9. 6. 88

All houses cut off



Tried the maximum load on the multiple dynamo. The maximum indicated current on the spiral ammeter was 440 + 220 = 660. Used the single ring ampere meter whose mean diam is 9.85 + 14.0 / 2 = 11.925 and whose mean radius is consequently 6. The highest reading reached on its scale giving 45° deflection was 29.4 corresponding to 762 amperes. The volts were about 100 (indicating) about 100 H.P. The main belt refused to transmit this full power. The charging current for the full (24 magnets in multiple arc) was about 75 amperes.

The range of the long ampere meter is up to 18,000 amperes in this vicinity H being 0.19.

$$M = \frac{r^2}{2} H \tan\theta$$

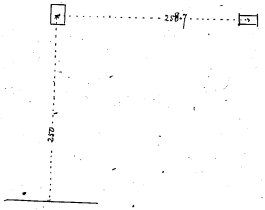
$$= \frac{(2587)^2 \times 10^4 \times 0.189 \times 5}{500}$$

$$= 17.3126 \times 0.189 \; 5 \times 10^4$$

$$= 3.4628 \times 0.189 \; 5 \times 10^4$$

$$= .6545 \times 10^4 \; 5$$

$$= 6545 \; 5$$



Four series of observations were taken
1st without any core
2nd with Fe Br in glass tube
3rd " Cast iron filings in paraffine wax
4th

No	Range in ch	Res: in ch	Shock Tap.	Current in abs. ch	Calculated Magnet Moment	Observed Magnetomet. B	Calculated Magnetic Field B	Magnetic Field in Lines NEW				
1	0	∞	0	0	0	0	0	0				
2	17	820	0·03	0·0157	1127	0·19	1246	23·1				
3	-		0·05	0·0262	1978	0·29	1901	38·5				
4	-		0·10	0·0524	3756	0·62	4065	77·1				
5	-		0·20	0·1048	7512	1·27	8326	154·2				
6	-		0·30	0·1572	11269	1·89	12391	231·3				
7	-		0·40	0·2096	15025	2·53	16587	308·3				
8	-		0·50	0·2621	18781	3·19	21,360	385·4				
9			0·60	0·3145	22537	3·83	25110	462·5				
10			0·70	0·3669	26293	4·42	28.978	539·6				
11			0·80	0·4193	30050	5·19	34026	616·7				
12			0·90	0·4717	33806	5·85	38353	693·8				
13			1·00	0·5241	37562	6·55	43139	770·9				
14			1·20	0·6289	45074	7·765	50908	925·0				
15			1·40	0·7337	52587	8·99	58939	1079·2				
16			1·58	0·8281	59348	10·67	67497	1218·0				
17			1·72	0·9015	64607	10·86	73478	1325·9				
18												
19												

No. Reading	Magnet in Coil	Pier in coil	Shunt Ohms	Current	Field H	Magnetic Moment S.	Moment of Coil rotor.	Moment of coil only	Moment of armatu	Magnetisation I	K	μ	Induction B
1	17	/	0.03	0.0157	23.1	0.2116	14403	124657	157				
2	"		0.05	0.0262	38.5	0.330	21664	19017	263				
3	"		0.10	0.0524	77.1	0.667	42373	40665	308				
4	"		0.2	0.1048	154.2	1.294	84484	83226	158				
5	"		0.3	0.1572	231.3	1.846	121103	123391	−288				
6	"		0.4	0.2096	308.3	2.550	167118	165587	131				
7	"		0.5	0.2621	385.4	3.223	211130	213360	−230				
8	"		0.6	0.3145	462.5	3.823	250664	251100	−46				
9	"		0.7	0.3669	539.6	4.466	291148	289978	170				
10	"		0.8	0.4193	616.7	5.154	337790	341026	−236				
11	"		0.9	0.4717	693.8	5.794	379786	383353	−347				
12	"		1.0	0.5241	770.9	6.344	422444	423139	−695				
13	"		1.2	0.6289	925.0	7.320	501613	509668	−295				
14	"		1.4	0.73375	1079.2	9.198	603203	589939	+13264				
15	"		1.58	0.8281	1218.	10.120	663148	674497	−1149				
16	"		1.72	0.9015	1325.9	11.095	727440	734478	−738				

Friday 14th June.

Took off accumulator cell after 95 hours continuous charging from a 5 cell Lalande battery, the charging current having in that time fallen from 5 to 0 ampères. Taking the average current at 2 ampères would give a total of 190 ampère hours = 190 × 3600 coulombs = 684,000 coulombs = 153 g. 000 Joules. The sp. g. is 1·075. The Lalande battery gives 2 amps: through the small H.B. ammeter.

The accumulator gives 2·6 ampères through the same ampèremeter.

Set the 3 Robert Brewodt cells to work as follows:—

Each cell containing 2 zinc plates each weighing 4 lbs = 1814 grammes and exposing (35·6 × 15·1) thickness (0·18 cm) = 538 sq. cms. The total weight of zinc in each cell is 3628 g. and total active area 2152 sq. cms.

Also 3 carbon plates weighing 2 lbs = 907 g. and their dimensions (40 × 17·4) thickness (0·327 cm) the total area would be about 700 sq. cms. on each side of plate and the active surface varies but would be about 60% of this or say 420 sq. cms. The total active carbon area in each cell is thus about 1680 sq. cms.

The active liquid in each cell is about 6800 c.c. and salt water solution is poured to within an inch and a half of the zinc tops, say about 7000 c.c. so that the total solution may be about 8500 c.c.

Date	Time	Hours at work	EMF	Roberts & Bakewort ~~E~~	~~I.R.~~	Tube Work Date	Alle Work Date	EMF	E.	I.R.
15.6.88	8.15	0	2.128	3.756	0.066					
	9.15	0.5	2.098	4.056	0.017					
	10.00	1	2.066	4.032	0.012					
	11.00	2	2.072	4.024	0.015					
16.6	8.30	24	2.032	3.884	0.023					
	15.30	31	2.042	3.886	0.025					
17.6	8.40	55	1.978	3.776	0.047					
18.6	8.30	71½	1.922	3.800	0.005					
14.6.88	8.0	55	1.878	2.130	0.104					
	10.0	105	1.078	1.776	0.108					
20.6.88	8.0	119	0.618	1.016	0.108					
	12.0	124	0.594	0.982	0.101					
	18.00	129	0.476	0.922	0.105					
21.6.88	8.0	143	0.473	0.816	0.104					
	18.00	153	0.424	0.776	0.095					
22.6.88	8.0	167	0.402	0.764	0.081					
	10.0	171	0.470							
13.6.88	8.00	0	2.096	3.700	0.066					
	9.15	0.5	2.062	3.800	0.070					
	12.00	3	1.995	3.476	0.074					
	17.30	8	2.006	3.496	0.061					
14.6	8.00	24	1.946	3.384	0.080					
	15.30	31	1.962	3.200	0.105					
16.6.88	8.30	55	1.826	3.124	0.084					
18.6	8.30	71½	1.700	2.860	0.094					
19.6.88	8.0	95	1.197	2.036	0.074					
	10.0	105	1.036	1.436	0.073					
20.6.88	8.0	119	0.595	1.022	0.083					
	12.0	124	0.577	1.000	0.072					
	18.0	129	0.528	0.996	0.080					
21.6.88	8.0	143	0.478	0.948	0.063					
	18.0	153	0.460	0.848	0.062					
22.6.88	8.0	167	0.461	0.800	0.076					
	10.0	171	0.442							
13.6.88	9.00	0	2.110	3.796	0.056					
	9.15	0.5	2.074	3.610	0.060					
14.6.88	7.00	2	2.010	3.536	0.068					
	7.00	8	2.009	3.528	0.069					
16.6.	8.15	24	1.966	3.408	0.077					
	15.30	31	1.965	3.372	0.073					
17.6.88	8.0	55	1.844	3.152	0.085					
18.6.88	8.30	71½	1.800	2.800	0.111					
19.6.88	8.0	95	1.142	1.948	0.087					
	10.0	105	0.748	1.576	0.088					
20.6.88	8.0	119	0.580	0.992	0.094					
	12.0	124	0.580	0.944	0.095					
	18.0	129	0.516	0.896	0.075					
21.6.88	8.0	143	0.452	0.820	0.071					
	18.0	153	0.480	0.800	0.080					
22.6.88	8.0	167	0.470	0.714	0.073					
	10.0	171	0.442							

These Roberts cells were charged on the 11th June and were set to work at 8.45 on the 15th June. They then were discharged continually through 0.5Ω of platinoid wire 0.084 cm. (0.033") in diam. 6 strands in multiple arc: The Potentiometer reading were

Time	Hours at work	Cell no.	P.D.	EMF	E.	I.R.
15.6.88 8.45	0	1	1.878	2.128	3.756	0.066
		2	1.850	2.096	3.700	0.066
		3	1.898	2.110	3.796	0.056
16.6.88	23	1	2.016	2.066	4.032	0.012
		2	1.998	1.996	3.476	0.074
		3	1.768	2.010	3.536	0.068
17.6.88	8	1	2.022	2.072	4.044	0.015
		2	1.748	2.006	3.496	0.061
		3	1.764	2.008	3.528	0.069
17.6.88 8.15	23½	1	1.942	2.032	3.884	0.023
		2	1.693	1.964	3.386	0.080
		3	1.703	1.966	3.406	0.077
12.6.88 7.15	8½	1	2.028	2.098	4.056	0.017
		2	1.770	2.020	3.540	0.070
		3	1.855	2.074	3.610	0.060
16.6.88 15.30	31	1	1.943	2.042	3.886	0.025
		2	1.620	1.962	3.240	0.105
		3	1.686	1.965	3.372	0.073
17.6.88 16.0	55	1	1.576	1.844	3.152	0.085
		2	1.562	1.826	3.124	0.084
		3	1.888	1.976	3.776	0.047
18.6.88 8.30	71½	1	1.900	1.922	3.800	0.005
		2	1.430	1.700	2.860	0.094
		3	1.400	1.713	2.800	0.111

Saturday 15th June

The accumulator cell failed to work on the pattern motor after 24 hours running. The estimated current during that time being 200 ampères the total energy expended would be:

200 × 24 × 3600 = 17,280,000 Joules.

A ground on one of the mains in the Bunkie branch of the Edison lighting circuit was found to be in a length of pipe just inside the field on Bunkie's premises. It was the first tube clear of the fence or the third from the box at the Eastern side of the road where it makes a 45° crossing. The tube was removed and replaced. The pressure wires are separate and disconnected in every length between the road box above mentioned and the 5th box in the field or rather during that is to say for 5 lengths.

Took following observations for the determination of effect of mass in core of magnet with the same winding.

Wound 46 metres of cotton-covered wire 0·027" in 3145 turns on the cylinder of cast iron used in the ordinary permeability experiments the dimensions of which are (6" × 1¼ diam.) or 15·2 and 31·75 cm.

Also wound 46 metres of cotton-covered wire 228 turns on the cylinder (6" × 2⅞) or 15·2 × 6·27

The calculated ratio should have been $\frac{3145 \cdot 5}{228 \cdot 6} = 13$

A series of 5 currents was sent through each coil and core and the magnetometer readings taken:-

Coil:	Bench D:	G:	Mag. Defln.
Large.	0·251		0·26
Small.			0·21
Large	0·100		0·51
Small			0·475
Large	0·299		1·545
Small			1·490
Large	0·500		2·60
Small			2·55
Large	0·800		4·21
Small			4·13.

The ~~calculated~~ ratio of the magnetic forces is as follows:—

The magnetic field in a solenoid is $\frac{4\pi Nc}{l}$ where N is the total no: of turns, l is the length and c is the current in abs: measure.

The permeability μ would cause an induction of $\frac{4\pi\mu Nc}{l}$ = induction per sq. cm. over a given area & the induction would be $\frac{4\pi\mu Nca}{l}$

Now assuming that the vol: of the coil is the same as that of the core, the total induction in the two cores would be as 314·5 : 456 = 1·45.

The moment of the large coil + l × 4π ~~same~~ = Induction (total) La and × $\frac{4\pi}{l}$ = f

			leads	mains
In Burke House				
Res: of + and −		1.504	0.7225	0.4385
- - + " 0		1.573	0.754	0.789
- - − " 0		1.572	0.782	0.790
			2.0175	
			1.0088	
		+ Main	0.2188	
		− "	0.2198	
		0 "	0.5703	
Of these as far as the EB		+	0.128	
		−	0.128	
		0	0.322	
Leaving from E.B. to Burke		+	0.091	
		−	0.092	
		0	0.248	

Taking the res: of the mains at 7.15×10^{-5} this would make the distance from E.B. to Burke's House 1280 feet. = 427 yds.

Tests for localization of Ground in Burke mains: 27

Monday 18th June.

Res: of leads to terminal board				0.075
" - these and leads to E.R.				Res leads
+ −	0.7225	+ =	0.3622	0.325
+ 0	0.754	−	0.3602	0.325
− 0	0.782	0 =	0.4227	0.365
	2.2885			
	1.1442			

Res: of cct composed as follows:

Leads to E.R. + and −	0.7225
To Burke's house leads joined these + and −	1.1610
	0.4385
Res: of mains to E.B. 2 × 0.1275	0.2550
- - - from EB to Burke's.	0.1835

Barley Loop. 1000/100 added Res: to − 0.198
whence D. of F = 0.499 " from bridge
Lead to E = 0.360
D. of F. from ER 0.129

Barley Loop 1000/100 Added Res: to 0.154
Whence D of F = 0.496 " from bridge
lead to F 0.360
D. of F from ER 0.136

Barley loop - 1000/10 Added Res: to − 65.79
Whence D of F = 0.498 " from bridge
lead to ER. 0.360
D. of F from " = 0.138 " "

Taking the distance from the E.R. at 0.138
and the leads to the E.B. at 0.1275
Makes dist: of fault from EB 0.0105

If the mains have a res: of 7.15×10^{-5} this corresponds to a distance of 147 feet say ¼ length of pipe from E.B.

Tests for comparison of Clark standard cells.

1·43 volts gave 121 divs: thro the astatic 5th Lord Kelvin (at Temp 19·5) and 52 of Carbon res:
Under these circumstances 1 div. corresponds to 0·00002 volt
(Assuming) that cell no 1 of the Newark set was 1·4300

then		2	1·42994
"		3	1·43000
"	English	1	1·43044
		2	1·4303

The difference between the Newark cells is within 0·00012 volt,
" " " " English " " 0·00010 "
The greatest observed deflection has been 50 divs: (probably) due to temp: diff only but this would mean 0·001 volt or 1 part in 1430

The mean difference may be fairly placed at 20 divs = 0·0004 volt or 1 part in 3575 = 0·028%

Proto sulphide of iron as grey powder [illegible] in glass tube Vol. 21.4 Mass 30.4 Density 1.4[illegible]
between corks without paraffin wax

Observed Obach Defltn.	Required Obach observation = ampères × 0.690	Res: in cct:	Required Current in abs. meas:	Magnetr Defl.n	Corrected Defl. to Wg. c.	Moment of Coil + core	Moment of coil	Moment of core	I	K	μ	𝔅 Ind: per sq. cm
0	0	∞	0	0	0	0	0	0	0	0	0	0
0.0295	0.03		0.0157	0.20	0.204	1337.	1246	91	0.43	0.018	1.226	28.32
0.0505	0.05		0.0262	0.32	0.317	2078	1901	177	0.84	0.0218	1.274	49.05
0.10	0.10		0.0524	0.685	0.685	4491	4065	426	2.02	0.0262	1.329	102.5
0.20	0.20		0.1048	1.315	1.315	8621	8326	295	1.39	0.00901	1.113	171.6
0.298	0.3		0.1572	1.985	1.998	13099	12391	708	3.35	0.0145	1.182	273.4
0.395	0.4		0.2096	2.560	2.592	16993	16587	406	1.97	0.00639	1.0803	333.1
0.501	0.5		0.2621	3.25	3.244	21268	21360	−92	−0.44	0.00114	1.0143	390.9
0.599	0.6		0.3145	3.90	3.907	25615	25110	505	2.43	0.00525	1.0660	493
0.698	0.7		0.3669	4.55	4.563	29915	28978	937	4.48	0.00830	1.1043	595.9
0.800	0.8		0.4193	5.22	5.220	34223	34026	197	0.93	0.00151	1.0190	628.4
0.9015	0.9		0.4717	5.98	5.971	39146	38353	93	0.44	0.00063	1.0079	699.3
1.005	1.0		0.5241	6.65	6.616	43375	43139	236	1.12	0.00145	1.0182	784.93
1.190	1.2		0.6289	7.88	7.948	52108	50908	1200	5.68	0.00614	1.0772	996.4
1.405	1.4		0.7338	9.30	9.268	60762	58939	1823	8.62	0.00799	1.1004	1187.6
1.60	1.58		0.8281	10.59	10.456	68551	67497	1054	4.99	0.00410	1.0515	1280.7
1.67	1.72		0.9015	11.06	11.39	74674	73478	1196	5.66	0.00427	1.0537	1397.1

Hydrometer [illegible] by [illegible]

Mass 490 · Density 2·32.

Observed Weight Deflection	Required Weight Deflection	C. required in the mass	Observed Weight Deflection	Corrected Deflection for C.	C	K	Moment of Coil + core	Moment of Coil	Moment of core	I	κ	μ	L
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0·0305	0·03	0·0157	0·605	0·595	23·1	3901	1246	2655	12·96	0·561	9·05	186·0
0·050	0·05	0·0262	0·80	0·780	38·8	5114	1901	3213	15·68	[illegible]	6·115	235·4
0·0985	0·10	0·0524	1·19	1·167	77·1	7651	4065	3586	17·50	0·229	3·853	297·1
0·202	0·20	0·1048	2·20	2·119	154·2	13892	8324	5566	27·17	0·176	3·212	405·3
0·302	0·3	0·1572	3·10	3·00	231·3	19668	12391	7277	35·52	0·154	2·930	677·7
0·40	0·4	0·2096	3·91	3·81	308·3	24979	16587	8392	40·96	0·153	2·670	823·2
0·50	0·5	0·2621	4·25	4·13	385·4	27077	21360	5717	27·91	0·072	1·910	734·1
0·60	0·6	0·3145	5·6	5·56	462·5	35796	25110	10686	52·16	0·113	2·417	1117·9
0·697	0·7	0·3669	6·42	6·287	539·6	41219	28978	12240	59·75	0·1107	2·391	1290·2
0·80	0·8	0·4193	7·295	7·115	616·7	46647	34026	12621	61·56	0·0998	2·254	1390·0
0·89	0·9	0·4717	8·04	7·929	693·8	51983	38353	13630	66·53	0·0957	2·205	1529·8
0·992	1·0	0·5241	8·85	8·679	770·9	56900	43129	13761	67·17	0·0871	2·095	1615·0
1·185	1·2	0·6289	10·33	10·187	925·0	66787	50908	15879	77·51	0·0838	2·053	1899·0
1·41	1·4	0·7338	12·12	11·767	1079·2	77146	58929	18207	88·88	0·0834	2·048	2210·2
1·585	1·58	0·8281	13·5	13·18	1218·	86409	67497	18912	92·32	0·0757	1·953	2378·8
1·77	1·72	0·9015	14·89	14·23	1326.	93293	73478	19815	96·72	0·0730	1·917	2541·8

6

Cast iron filings in glass tube with paraffin wax. Volume 1865 mm³
Density 2·04

Observed Hook Deflec.	Hook Deflec: required	Ib: in abs: measure	Observed Mag. Deflec.	Corrected M.D. deflec.	Moment of Coil raw	Moment of Coil	Moment of Core	I	H	k	μ	L
0	0	0	0	0	0	0	0	0	0	0	0	0
0·027	0·030	0·0157	0·535	0·534	3894	1246	26148	14·23	23·1	0·616	8·741	191·7
0·050	0·05	0·0262	0·750	0·737	4917	1907	3076	16·21	38·5	0·421	6·290	242·2
0·10	0·1	0·05244	1·25	1·25	8195	4065	4130	22·20	77·1	0·288	4·619	356·1
0·198	0·2	0·1048	2·21	2·23	14620	8324	6304	33·89	154·2	0·2198	3·762	580·1
0·298	0·3	0·1572	3·2	3·22	21,111	12,391	8720	46·88	231·3	0·2027	3·547	824·4
0·398	0·4	0·2096	4·185	4·206	27,875	16,587	10988	59·07	308·3	0·1916	3·408	1050·7
0·500	0·5	0·2621	5·11	5·11	33,502	21,360	12142	65·28	385·4	0·1941	3·129	1205·9
0·597	0·6	0·3145	6·02	6·05	39,664	25,110	14554	78·25	462·5	0·1692	3·126	1445·8
0·700	0·7	0·3669	6·985	6·98	45,762	28,978	16784	90·24	539·6	0·1672	3·101	1673·3
0·798	0·8	0·4193	7·835	7·853	51,485	34,026	17459	93·86	616·7	0·1521	2·911	1795·2
0·902	0·9	0·4717	8·8	8·78	57,563	38,353	19210	103·27	693·8	0·1488	2·870	1991·2
1·020	1·0	0·5241	9·7	9·67	63,397	43,139	20258	108·91	770·9	0·1413	2·776	2140·0
1·185	1·2	0·6289	11·24	11·38	74,608	50,908	23700	127·42	925·0	0·1377	2·730	2525·
1·400	1·4	0·7338	13·05	13·05	85,557	58,939	26618	143·11	1079·2	0·1326	2·666	2871
1·580	1·58	0·8281	14·8	14·8	97,030	67,497	29,533	158·78	1218·0	0·1304	2·639	3214
1·660	1·72	0·9015	15·32	15·87	104,045	73,478	30,567	164·34	1325·9	0·1239	2·557	3390
0												

Remarks. Show the [illegible] Volume 198·3 Density 2·77
Mass 550.

Block Depth observed	Block Depth required	δ in abs. mean	Observed Magnetic Deflen.	Corrected Magnetic Deflen.	Moment of Coil tare	Moment of Coil	Moment of Core	I	H	k	μ	L
0	0	0	0	0	0	0	0	0	0	0	0	0
0·03	0·03	0·0157	0·49	0·48	3147	1246	1901	9·59	23·1	0·415	6·215	143·6
0·05	0·05	0·0262	0·71	0·70	4589	1901	2688	13·55	38·5	0·352	5·423	208·8
0·101	0·1	0·0524	1·3	1·16	7605	4065	3540	17·85	77·1	0·232	3·909	301·4
0·204	0·2	0·1048	2·4	2·33	15276	8326	6950	35·04	154·2	0·227	3·853	594·1
0·296	0·3	0·1572	3·39	3·405	22322	12391	9933	50·08	231·3	0·217	3·721	860·7
0·394	0·4	0·2096	4·39	4·426	29017	16557	12430	62·67	308·3	0·2033	3·555	1096·0
0·492	0·5	0·2621	5·32	5·365	35173	21360	13813	69·65	385·4	0·1807	3·271	1280·6
0·590	0·6	0·3145	6·35	6·368	41749	25110	16639	83·90	462·5	0·1814	3·280	1517·0
~~0·688~~	0·7	0·3669	7·3	7·292	47807	28978	18829	94·94	539·6	0·1759	3·210	1732·1
0·800	0·8	0·4193	8·29	8·174	53590	34026	19564	98·64	616·7	0·1599	3·009	1855·7
0·902	0·9	0·4717	9·13	9·040	59267	38353	20914	105·45	693·8	0·1520	2·910	2019
0·992	1·0	0·5241	9·95	9·930	65102	43139	22063	111·24	770·9	0·1443	2·813	2169
1·190	1·2	0·6289	11·35	11·870	75854	50908	24946	125·78	925·0	0·1359	2·708	2505
1·385	1·4	0·7338	13·39	13·050	85754	58939	26815	135·20	1079·2	0·1253	2·574	2778
1·580	1·58	0·8281	14·55	14·560	95457	67497	27960	140·99	1218·	0·1158	2·455	2990
1·785	1·72	0·9015	16·22	15·520	101882	73478	28404	143·21	1326·	0·1080	2·357	3125
~~1·785~~												

(2)

Coil set at greater dist: from needle for min cur

Obd. Obsd. Deflection	Required Obsd.	Current in abs: units.	H.	Observed Magnetic Diff.	Corrected Magnetic Diff.	Moment from this Deflec.	of Mag. Bar	Calculated from Diff. Page 31
0·031	0·03	0·0157	23·1	0·075	0·0823	1395	12477	12469
0·0495	0·05	0·0262	38·5	0·115	0·1162	1969	1878	1901
0·102	0·10	0·0524	77·1	0·22	0·2255	3821	3756	10265
0·206	0·20	0·1048	154·2	0·449	0·4495	8389	7512	8326
0·299	0·30	0·1572	231·3	0·715	0·732	12405	11249	12391
0·400	0·40	0·2096	308·3	0·970	1·00	16947	15225	16587
0·508	0·50	0·2621	385·4	1·220	1·25	21183	19291	21360
0·598	0·60	0·3145	462·5	1·46	1·505	25505	22537	25110
0·698	0·70	0·3669	539·6	1·72	1·775	30080	26493	28978
0·800	0·80	0·4193	616·7	2·00	2·05	34741	30050	34028
0·900	0·90	0·4717	693·8	2·23	2·29	38808	33906	38357
1·00	1·00	0·5241	770·9	2·48	2·56	43386	37762	43139
1·190	1·20	0·6289	925·0	2·91	3·005	50,925	45070	50908
1·440	1·40	0·7338	1079·2	3·33	3·50	59,318	52587	59899
1·60	1·58	0·8291	1218·0	4·06	4·088	69,278	59,948	67147
1·83	1·72	0·9015	1325·9	4·58	4·38	76,227	66,607	73478

Obd. Obsd. Deflection	Required Obsd. Deflection	Current in abs. units	Observed Magnetic Diff.	Corrected Magnetic Diff.	Moment of Bar + rem	Moment of Coil	Moment of Bar + rem	Moment of Coil	I	H	K	μ	L
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0·03	0·0157	0·35	0·35	0·35	17311	13395	15316	14142	23·1	23·1	0·8949	11·67	2646
0·05	0·0262	0·63	0·63	0·63	7387	1969	6396	8897	38·5	38·5	0·5798	8·51	327·7
0·10	0·0524	0·61	0·97	1·03	1·02	3821	3522	12·4·93	77·1	77·1	0·253	5·444	449·3
0·20	0·1048	1·08	1·02	1·36	1·363	8389	8389	16947	154·2	154·2	0·200	4·14	658
0·30	0·1572	1·72	2·10	2·40	2·73	12405	16947	21183	231·3	231·3	0·169	3·12	811·5
0·40	0·2096	2·10	2·73	3·085	3·40	16947	21183	25505	308·3	308·3	0·156	2·96	1044·8
0·50	0·2621	2·48	3·40	3·88	4·38	21183	25505	30080	385·4	385·4	0·131	2·52	1360
0·60	0·3145	2·91	3·88	4·38	4·88	25505	30080	34741	462·5	462·5	0·116	2·46	1512
0·70	0·3669	3·33	4·38	4·88	5·39	30080	34741	38808	539·6	539·6	0·111	2·39	1657
0·80	0·4193	3·83	4·88	5·39	5·92	34741	38808	43386	616·7	616·7	0·108	2·36	1820
0·90	0·4717	4·32	5·39	5·92	6·45	38808	43386	50925	693·8	693·8	0·104	2·31	2137
1·00	0·5241	4·84	5·92	6·45	7·00	43386	50925	59318	770·9	770·9	0·1027	2·29	2471
1·20	0·6289	5·90	7·00	7·55	8·15	50925	59318	69278	925·0	925·0	0·0977	2·10	2957
1·40	0·7338	6·97	8·15	8·75	9·35	59318	69278	76227	1079·2	1079·2	0·0894	2·07	3744
1·58	0·8291	7·87	9·35	9·95					1218·0	1218·0			
1·72	0·9015	8·58	9·95						1325·9	1325·9			

59. Manganese Core Volume 231 · Mass 1673 Density 7.22.

Clock Obsd	Diff'l Correct	C. in abs. u.	Magnetic Diff'n Observed	Correctd	Moments Coil from Coil	Core	T	H	κ	μ	L.
0.031	0.03	0.0157	0.46	0.1445	75741	1395	6146	26.6	23.1	1.152	15.48	357.6
0.05	0.05	0.0262	0.62	0.62	10507	1969	8538	36.9	38.5	0.958	13.04	5020
0.102	0.10	0.0524	1.10	1.079	18255	3821	14464	62.6	77.1	0.812	11.21	8642
0.205	0.2	0.1048	2.23	2.176	36876	8389	28487	123.3	154.2	0.800	11.05	17040
0.30	0.3	0.1572	3.27	3.27	55416	12405	43011	186.1	231.3	0.804	11.10	2567
0.402	0.4	0.2096	4.37	4.348	73684	16947	56737	245.5	308.3	0.796	11.00	3391
0.5035	0.5	0.2621	5.44	5.343	90885	21183	69702	301.5	385.4	0.782	10.83	4173
0.6045	0.6	0.3145	6.25	6.204	105137	25505	79632	344.5	462.5	0.745	10.36	4791
0.698	0.7	0.3669	7.23	7.25	122864	30980	92784	401.4	539.6	0.737	10.26	5536
0.797	0.8	0.4193	8.11	8.114	137946	34741	103205	446.4	616.7	0.724	10.10	6228
0.892	0.9	0.4717	8.89	8.969	151995	38808	113187	489.6	693.8	0.705	9.86	6841
0.993	1.0	0.5241	9.7	9.768	165535	43384	122151	528.7	770.9	0.686	9.62	7417
1.203	1.2	0.6289	11.33	11.3	191498	50925	140573	608.0	925.0	0.657	9.26	8566
1.42	1.4	0.7338	12.82	12.64	214206	59313	154893	669.9	1079.2	0.621	8.80	9495
1.65	1.58	0.8281	14.44	13.54	229458	69278	160180	692.8	1218	0.569	8.15	9924
1.75	1.72	0.9015	15.7	15.43	261488	74227	187261	810.1	1325.9	0.611	8.68	11508

Last Obs. Volume 2.4 Mar. 1651 Density 7.6

Magnetic Deflection Ord	C Required	C Obtd.	Magnetic Defl. Corrected	Moments Bott + core	Bott Coil	Core	I	H	k	μ	L
0.031	0.03	0.0157	0.35	0.339	57145	13195	43350	18.8	23.1	0.814	11.23	259.4
0.05	0.05	0.0242	0.58	0.58	98229	19669	78560	34.0	38.5	0.883	12.10	465.8
0.101	0.10	0.0524	1.12	1.109	187194	38271	148923	64.8	77.1	0.840	11.56	891.1
0.2.03	0.2	0.1148	2.23	2.188	370719	83829	286890	124.1	154.2	0.805	11.12	1714
0.3.0	0.3	0.1572	3.33	3.32	562263	124605	438858	189.7	231.3	0.820	11.31	2616
0.4.0	0.4	0.2096	4.46	4.45	754413	169467	584466	252.9	308.3	0.820	11.31	3486
0.5.005	0.5	0.2621	5.55	5.534	937833	211833	726000	314.1	385.4	0.815	11.24	4331
0.6.	0.6	0.3145	6.70	6.69	1133733	255505	878868	380.1	462.5	0.821	11.32	5235
0.7	0.7	0.3669	7.75	7.73	1309998	300050	1009948	436.5	539.6	0.801	11.07	5973
0.7.97	0.8	0.4193	8.69	8.70	1474887	347461	1127426	487.7	616.7	0.791	10.94	6747
0.8.96	0.9	0.4717	9.64	9.663	1637366	398808	1244948	540.5	693.8	0.779	10.79	7485
1.02	1.0	0.5241	10.61	10.382	1759461	433884	1325587	573.4	770.9	0.744	10.35	7979
1.21	1.2	0.6289	12.61	12.28	2088105	509925	1571180	679.8	925.0	0.735	10.24	9470
1.45	1.4	0.7338	14.21	13.72	2325909	593313	1731196	749.1	1079.2	0.694	9.72	10486
1.56	1.58	0.8281	15.02	15.19	2572251	692278	1879973	813.0	1218.0	0.668	9.39	11436
1.72	1.72	0.9015	16.2	16.17	2740028	740227	1998801	984.4	1325.9	0.745	29.86	13448

Cast wrought iron imperfect casting Mr. Jas. Mason 17th December 1866

Obsch Obst	Defln Required	C. abs. K.	Magnetic Observed	Defln Corrected	Moments Girl + cow	Coil	Core	I	H	K	μ	L
0.03	0.03	0.0157	0.4	0.393	6660	1395	5265	22.8	23.1	0.987	13.40	309.5
0.0501	0.05	0.0262	0.6	0.599	10151	1969	8182	35.4	38.5	0.919	12.55	483.1
0.102	0.10	0.0524	1.15	1.138	19285	3821	15464	66.9	77.1	0.8768	11.91	918.2
0.205	0.20	0.1048	1.26	2.225	37706	8389	29317	126.8	154.2	0.822	11.33	1747
0.299	0.30	0.1572	3.3	3.341	56619	12405	44214	191.3	231.3	0.827	11.39	2634
0.398	0.40	0.2096	4.47	4.523	76650	16947	59703	258.3	308.3	0.838	11.53	3564
0.505	0.50	0.2621	5.59	5.475	92783	21183	71600	309.8	385.4	0.804	11.10	4277
0.595	0.60	0.3145	6.58	6.675	113119	25505	87614	379.0	462.5	0.819	11.29	5221
0.698	0.70	0.3669	7.72	7.792	132049	30050	101969	441.1	539.6	0.809	11.17	6027
0.797	0.80	0.4193	8.76	8.792	148995	34741	114254	494.4	616.7	0.801	11.06	6820
0.899	0.90	0.4717	9.79	9.86	167096	38808	128286	552.9	693.8	0.800	11.05	7666
1.	1.0	0.5241	10.87	10.87	184211	43384	140827	609.1	770.9	0.790	10.93	8424
1.21	1.2	0.6289	12.78	12.67	214715	50925	163790	705.4	925.0	0.766	10.63	9832
1.43	1.4	0.7338	14.49	14.19	240474	59313	181161	783.5	1079.2	0.726	10.12	10918
1.585	1.58	0.8281	15.47	15.42	261318	69278	192040	830.7	1218.0	0.682	9.57	11655
1.79	1.72	0.9015	16.75	16.27	275723	74227	201496	871.5	1325.9	0.657	9.26	12279

Water iron core Volume 231 [redacted] 1815 [redacted]

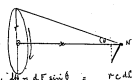
Orach. Obs.	Defl. required	C. abs. w.	Magnet. Defl. Observed	Corrected	Moments Coil + core	Coil	Core	I	H	k	μ	δ
0.0305	0.03	0.0157	0.32	0.315	5338	1395	39443	17.05	23.1	0.738	10.27	237.2
0.05	0.05	0.0242	0.55	0.555	9405	1969	7436	32.16	38.5	0.835	11.49	442.3
0.1	0.1	0.0524	1.125	1.135	19235	3821	15414	66.67	77.1	0.865	11.87	915.1
0.203	0.2	0.1048	2.31	2.286	38740	8389	30351	131.30	152.2	0.851	11.70	1804
0.3	0.3	0.1572	3.44	3.44	58297	12405	45892	198.5	231.3	0.858	11.78	2724
0.4	0.4	0.2096	4.53	4.513	76769	16947	59822	258.7	308.3	0.839	11.54	3558
0.5	0.5	0.2621	5.71	5.74	97274	21193	76091	329.1	385.4	0.854	11.73	4520
0.6	0.6	0.3145	6.82	6.85	116075	25505	90580	391.8	462.5	0.847	11.64	5383
0.699	0.7	0.3669	7.99	8.04	136268	30080	106188	459.3	539.6	0.843	11.59	6254
0.795	0.8	0.4193	9.10	9.197	155859	34741	121,118	523.9	616.7	0.849	11.67	7196
0.90	0.9	0.4717	10.32	10.37	175737	38808	136929	592.3	693.8	0.855	11.74	8143
1.0	1.0	0.5241	11.5	11.55	195734	43384	152350	659.0	770.9	0.855	11.74	9050
1.235	1.2	0.6289	14.21	13.87	235857	50925	184,126	796.4	925.0	0.861	11.82	10933
1.43	1.4	0.7338	16.35	16.07	272333	57313	213020	921.4	1079.2	0.854	11.73	12655
1.58	1.58	0.8251	18.1	18.17	307922	69279	237,644	1032.2	1218.0	0.847	11.64	14176
1.8	1.72	0.9015	20.24	19.41	328935	74227	254,708	1101.7	1325.9	0.831	11.44	15168

Norway Iron core Volume 231 Mass 1885 g, Dec. 5, 1910

Applied Defl. Red.	Applied Defl. Required	Current in abs. units	Magnetic Defln. Red.	Magnetic Defln. Corrected	Moments Coil & core	Coil	Core	I	H	k	μ	L.
0.030	0.03	0.0157	0.325	0.320	5423	1395	4028	17.42	23.1	0.754	10.47	241.9
0.051	0.05	0.0262	0.590	0.579	9812	1969	7843	33.92	38.5	0.881	12.07	464.7
0.10	0.10	0.0524	1.125	1.105	19065	3821	15244	65.93	77.1	0.855	11.75	905.8
0.200	0.20	0.1048	2.35	2.304	39045	8389	30656	132.59	154.2	0.860	11.81	1821
0.302	0.30	0.1572	3.50	3.477	58921	12405	46519	201.21	231.3	0.870	11.93	2759
0.401	0.40	0.2096	4.68	4.673	79192	16947	62245	269.23	308.3	0.873	11.97	3690
0.502	0.50	0.2621	5.85	5.831	98816	21183	77633	335.8	385.4	0.866	11.88	4578
0.598	0.60	0.3145	6.98	7.013	118847	25505	93342	403.7	462.5	0.873	11.97	5536
0.70	0.70	0.3669	8.18	8.193	138844	30080	108764	470.4	539.6	0.872	11.96	6453
0.800	0.80	0.4193	9.420	9.377	158,909	34741	124168	537.1	616.7	0.871	11.94	7363
0.900	0.90	0.4717	10.62	10.570	179,127	38808	140319	606.9	693.8	0.875	12.00	8325
0.998	1.00	0.5241	11.70	11.74	198,954	43384	155570	672.9	770.9	0.873	11.97	9228
1.220	1.20	0.6289	14	14.185	240,389	50925	189464	819.5	925.0	0.886	12.13	11222
1.405	1.40	0.7338	16.65	16.61	281,285	59313	222172	996.1	1079.2	0.923	12.60	13595
1.600	1.58	0.8281	18.85	18.64	315,886	69278	246608	1066.7	1218.	0.876	12.01	14625
1.82	1.72	0.9015	20.95	19.83	336,053	74227	261826	1132.5	1325.9	0.854	11.73	15551
1.82												

Deflection	Tangent	Long. r^2+x^2	Ammeter $\frac{(r^2+x^2)^{3/2}}{2\pi r^2}$	Indicating Current in amperes $\times 10 \times 2.14$	Deflection	Tangent	Long. $x_{inc.}$ R_{Ohms}	x	r^2+x^2	$\frac{(r^2+x^2)^{3/2}}{2\pi r^2}$	Current in amperes $\times 10 \times 2.14$
1	11	157	7.017	15.32	31	41	1717				
2	12	180	8.697	16.52	32	42	1800	337.62	314.56	297.63	
3	13	205	10.676	20.28	33	43	1885	361.81	687.4		
4	14	232	12.976	24.65	34	44	1972	387.15	735.6		
5	15	261	15.622	29.68	35	45	2061	413.65	785.9		
6	16	292	18.641	35.42	36	46	2152	441.35	838.6		
7	17	325	22.059	41.91	37	47	2245	470.26	893.5		
8	18	360	25.903	49.22	38	48	2340	500.43	950.8		
9	19	397	30.198	57.38	39	49	2437	531.86	1010.5		
10	20	436	34.971	66.44	40	50	2536	564.60	1073		
11	21	477	40.248	76.47	45	55	2061	748.71	1422		
12	22	520	46.057	87.51	50	60	3636	969.29	1842		
13	23	565	52.423	99.60	55	65	4261	1229.7	2336		
14	24	612	57.373	112.81	60	70	4936	1533.1	2913		
15	25	661	66.934	127.17	65	75	5661	1883.0	3578		
16	26	712	75.131	142.75	70	80	6436	2282.7	4337		
17	27	765	83.992	159.58	75	85	7261	2735.3	5197		
18	28	820	93.543	177.73	80	90	8136	3246.4	6164		
19	29	877	103.81	197.24	85	95	9061	3813.1	7245		
20	30	936	114.82	218.16	90	100	10036	4444.4	8445		
21	31	997	126.60	240.54	95	105	11061	5142.9	9772		
22	32	1060	139.175	264.43	100	110	12136	5910.6	11230		
23	33	1125	152.57	289.88	105	115	13261	6751.2	12827		
24	34	1192	166.82	316.96	110	120	14436	7668.1	14569		
25	35	1261	181.94	345.7	115	125	15661	8664.6	16463		
26	36	1332	197.97	376.1	120	130	16936	9743.9	18513		
27	37	1405	214.92	408.3							
28	38	1480	232.93	442.4							
29	39	1557	251.72	478.3							
30	40	1636	271.61	516.1							
			292.55	555.8							

If a current flow in the ring the action of one element of this current dl on the needle at N will be $dF = \frac{c\,dl}{r^2+z^2}$



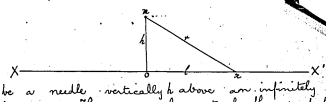
of this the horizontal component

will be $dH = dF \sin\theta = \frac{rc\,dl}{(r^2+z^2)^{3/2}}$

Summing these elementary actions we have $H = \frac{2\pi r^2 c}{(r^2+z^2)^{3/2}}$

And $c = \frac{H(r^2+z^2)^{3/2}}{2\pi r^2}$

For the long ampere meter $r = 6$ $2\pi r^2 = 226.2$



If n be a needle vertically h above an infinitely long wire XOX'. Then an element of the conductor situated at x exercises a force on n

$$dF = \frac{c\,dl}{h^2+l^2}$$

of which the horizontal component is

$$dH = \frac{c\,dl}{h^2+l^2} \times \frac{h}{\sqrt{h^2+l^2}} = \frac{ch\,dl}{(h^2+l^2)^{3/2}}$$

$$\int dH = ch\int_{-l}^{+l}\frac{dl}{(h^2+l^2)^{3/2}}$$ the integral is $\frac{l}{h^2(h^2+l^2)^{1/2}}$

whence $H = ch\left(\frac{+l}{h^2 l} - \frac{-l}{h^2 l}\right) = \frac{2c}{h}$

Wednesday 20th June.

The following observations were made with the view of determining H.

The Gauss Magnetometer was used as the H pair.

The scale was 250·85 distant from the mirror.

The time of oscillation with the magnet was determined by chronograph as follows:— 195 complete vibs: took place in 2262·82 secs. or 11·6041 secs per swing.

The amplitude was $\tan^{-1}\frac{7\cdot0}{250\cdot85}$ to $\tan^{-1}\frac{1\cdot6}{250\cdot85}$ in the line

Temp: 29° C.

When the magnet was loaded with the brass ring, the time of vib: became 25·315 secs: ·88 vibs being completed in 2227·72 seconds. The amplitude of angular motion being from $\tan^{-1}\frac{10\cdot94}{250\cdot9}$ to $\tan^{-1}\frac{1\cdot77}{250\cdot9}$ temp: 29·5° C.

Torsion $\frac{\pi}{2}$ + 2·482
$\frac{\pi}{2}$ − 2·538 } Mean 2·495 special suspension

The torsion with the unloaded magnet was
$\frac{\pi}{2}$ + 0·09
$\frac{\pi}{2}$ − 0·08 } Mean 0·085

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*The weight of the ring is 167·279 g. and its moment of inertia is 1087·31 cm. gm.

The time of oscillation for the unloaded magnet corrected for torsion is

$$t^2 = \frac{5400+v}{5400}(11.604)^2 \quad \text{where } v = \tan^{-1}\frac{0.085}{250.89}$$

$$= \tan^{-1} 0.000 3388 = 1'.15$$

$$t^2 = 1.000213 \times 134.6528 = 134.681$$

The time of oscillation for the loaded magnet corrected for torsion is

$$t^2 = \frac{5400+v}{5400}(25.315)^2 \quad \text{where } v = \tan^{-1}\frac{2.495}{250.9} =$$

$$= \tan^{-1} 0.009 9442 \qquad \therefore v = 34.3'.$$

$$t^2 = 1.006352 \times 640.8492 = 644.9199.$$

The moment of inertia of the magnet is

$$= \frac{134.681}{644.920 - 134.681} \times 1087.31$$

$$= \frac{134.681}{510.239} \times 1087.31 = \frac{146439.98}{510.239}$$

$$= 287.002$$

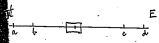
The time of oscillation $= \sqrt{134.681}$

$$\therefore MH = \frac{4\pi^2 \times 287.002}{134.681} = \frac{39.478 \times 287.002}{134.681}$$

$$= \frac{11330.3798}{134.681} = 84.1275$$

On the 30th of April see Book 2 p. 24 the product MH was 87.112.

The deflections were as follows.



Torsion $\frac{\pi}{2}$ − 0.42 −

$\frac{\pi}{2}$ + 0.41 +

Temp. 30°C.

Position	End of mount	Deflection
a	S	8.23 +
d	N	8.28 +
c	N	20.21 +
b	S	20.12 +
b	N	20.20 −
c	S	19.89 −
d	S	8.19 −
a	N	8.29 −
a	N	8.295 −
d	S	8.19 −
c	S	19.89 −
b	N	20.21 −
b	S	20.09 +
c	N	20.22 +
d	N	8.295 +
d	S	8.23 +

	a	d	b	c
−	8.23	+8.28	+20.12	+20.21
+	8.29	−8.19	−20.20	−19.89
+	8.295	−8.19	−20.21	−19.89
−	8.23	+8.295	+20.09	+20.22
	8.261	8.239	20.13	20.053
	8.250		20.091	

Scale dist. 213.5

The corrected deflections are

$$\frac{5400+v}{5400} \times 8.250 = 1.001222 \times 8.250 = 8.2601$$

$$\frac{5400+v}{5400} \times 20.091 = 1.001222 \times 20.091 = 20.1156$$

where $v = \tan^{-1}\frac{0.415}{213.5} = \tan^{-1} 0.001943 = 6.6'$

$$\tan^{-1}\frac{8.260}{213.5} = 0.038688 = 2^\circ.12'.55''$$
sin of which = 0.038663

$$\tan^{-1}\frac{20.1156}{213.5} = 0.094218 = 5^\circ.23'.57''$$
sin of which = 0.094094

$$p = \frac{\left(\frac{50}{2}\right)^3 \times 0.038663 - \left(\frac{37.5}{2}\right)^3 \times 0.094094}{25 \times 0.038663 - 18.75 \times 0.094094}$$

$$= \frac{2416.5 - 2481.0}{0.96658 - 1.7623} = \frac{-64.5}{-0.7957}$$

$$= 81.059.$$

$$\frac{M}{H} = \frac{1}{2}\left(50\right)^3 \times 0.038663 \left(1 - \frac{81.059}{(50)^2}\right)$$

$$= 125000 \times 0.193315 \times 0.9675764$$

$$= 2338.088$$

$$\therefore H^2 = MH \div \frac{M}{H} = \frac{84.12765}{2338.088} = 0.03598132$$

$$\therefore H = \underline{0.1897}$$

$$M^2 = MH \times \frac{M}{H} = 196697.66$$

$$M = 443.14. \quad @ \ 29.5^\circ \text{ c.}$$

On the 30th April, H was determined to be 0.1891 and M 0.4460.6 @ 22°.c.

Primary Batteries — Robert = Brevoort

Date & Time	Hours work	No.	P.D.	EMF	C.	I.R.	
9.6.88 8.00.	95	1	1·165	1·408	2·320	0·102	
		2	1·042	1·197	2·084	0·074	
		3	0·944	1·944	1·948	0·077	
9.6.88 18.00.	105	1	0·888	1·078	1·776	0·106	
		2	0·718	0·824	1·436	0·073	
		3	0·636	0·748	1·272	0·088	
20.6.88 8·00	119	1	0·588	0·618	1·016	0·108	
		2	0·511	0·575	1·022	0·083	
		3	0·496	0·580	0·992	0·094	
13·00	124	1	0·491	0·571	0·982	0·101	
		2	0·504	0·577	1·008	0·072	
		3	0·470	0·550	0·940	0·085	
18·00	129	1	0·476	0·576	0·952	0·105	
		2	0·498	0·548	0·996	0·070	
		3	0·448	0·516	0·896	0·075	
21.6.88 8·00	143	1	0·408	0·493	0·816	0·104	
		2	0·424	0·478	0·848	0·063	
		3	0·410	0·452	0·820	0·081	
18·00	153	1	0·398	0·474	0·796	0·075	
		2	0·424	0·460	0·848	0·052	
		3	0·400	0·480	0·800	0·100.	
22.6.88 8·00	167	1	0·384	0·462	0·768	0·101	
		2	0·400	0·461	0·800	0·076	
		3	0·392	0·450	0·784	0·073	
12·0	171	1	0·394	0·470			
		2	0·414	0·442			
		3	0·395	0·442.			

Cells taken down much H₂O being evolved & liquid lost

Friday. 22nd June.

Received at laboratory 10 antimagnetic Watches as follows —

Watch No.	Grade	Name.	Number	Price
1	1st	Paillard	57. 872	$ 67.50
2	2nd	"	56. 608	$. 22.50
3	3rd		350 4348	$ 7.50
4	1st	Waltham	3,457,605	$ 21.00
5	2nd		3,534,804	$ 18.00
6	3rd		3,511,918	$. 5.00
7	1st	Elgin + sup shill	3,073,718	$. 8.50
8	2nd		3,040,188	$ 6.25
9	1	Hampden	1,73,861	$ 8.50
10	1	Patek Philippe	76,772	—

Weighed meter plates and set them in solution of pure neutral $ZnSO_4$ 1.054 cleaned the zinc. but did not amalgamate them

Number	Weight	Combined weight	Number	Weight	Combined weight
1	21.2983	43.7064	11	20.2825	40.4863
2	22.4149		12	20.2032	
3	21.1228	43.1279	13	21.5329	42.7356
4	22.0048		14	21.2023	
5	21.6857	42.9366	15	21.3436	42.5194
6	21.2486		16	21.1554	
7	21.6872	43.1524	17	20.7749	41.2108
8	21.4277		18	20.4355	
9	22.0648	42.5334	19	21.9550	42.2935
10	20.4673		20	20.3381	

36 × 2·2 = 265

450 | 1370
1785
3730
2470

	Beyond Fixed Deflect.	Reversed Fixed Deflect.	Current in abs. units	Moment Magnetic Deflect.	Corrected Magnetic Deflect.	Moment of Coil rev.	Moment of Cont.	Moment of rev.	I"
Small coil	0·1	0·1	0·0524	0·06	0·06		357	1363	
	0·2	0·2	0·1048	0·11	0·11		652	7226	
	0·4	0·4	0·2096	0·205	0·205		1186	11452	
	0·6	0·7	0·3669	0·39	0·38		2213	25141	
	0·997	1·0	0·5241	0·51	0·525		3110	36230	
Large coil	0·1	0·1	0·0524	0·065	0·065		285		
	0·2	0·2	0·1048	0·10	0·10		592		
	0·4	0·4	0·2096	0·230	0·28		1660		
	0·7	0·7	0·3669	0·48	0·47		2790		
	1·0	1·0	0·5241	0·70	0·67		3970		
	0	0	0	0·03	0·03				
Small coil open	0·1	0·1	0·0524	0·41	0·41	2432	357	2075	
	0·2	0·2	0·1048	0·865	0·86	5100	652	4448	
	0·4	0·4	0·2096	1·75	1·75	10378	1186	9192	
	0·7	0·7	0·3669	3·08	3·11	18444	2213	16231	
	0·997	1·0	0·5241	4·42	4·48	26570	3110	23460	101·5
	0	0	0	0·03					
Large coil open	0·101	0·10	0·0524	0·401	0·406	2408	285	2023	
	0·200	0·2	0·1048	0·695	0·795	4714	592	4122	
	0·4	0·4	0·2096	1·69	1·71	10142	1660	8482	
	0·7	0·7	0·3669	3·01	3·04	18029	2790	15242	
	0·999	1·0	0·5241	4·41	4·45	26390	3970	22420	57·9
	0	0	0	0·05					

Friday 22nd June

Continued experiments on coil-winding as follows

40 metres of cotton-covered wire were wound on each of two brass core-cover. The mean diam: of the smaller coil was 4·69 cms that of the larger 6·47. The lengths of the coils were (16 cms) equal. There were 197 turns on the larger and 270 on the smaller. The dist: from coil centre to needle 238·5

" " " scale — — 2216

H	Ratio of H	Total Pow £					
		192					
		384					
		768					
		1544					
		4320					
		267					
		533					
		1066					
		1865					
		2665					
11·11		1910					
22·22		4006					
44·44		8151					
77·77		14425					
111·1	1·371	20870					
8·11	0·7295	1891					
16·21		3703					
32·42		7965					
56·74		14159					
81·06		20726					

Saturday 23rd June

Ran 2 armatures in the no 1. Machine
No 1 was of the ordinary type
- 2 had an core of oxydized iron wire instead of iron

No 2 Ran at an average speed of 3920 revs: from 10.22 to 11.22 with a charging current through its fields of 1.5 ampere. It had 44 coil of wire and its res: was 2.7Ω so that each coil had a res: of $\frac{5.4}{22} = .2245\Omega$

~~after~~ The voltage by 2 AP wires in series was 222 at that speed. As soon as it stopped it was immersed in a bath of about 43,200 c.c. of water, and allowing for the rise from the heat of the room, it caused a rise of temp: in 35 mins of 6°F (74°-68°) or about $\frac{259200}{9}$ calories

No. 1. Ran at an average speed of 3820 revs (some slip on belt) generating at the same velocity as no 2 (3920) 274 volts from 11.32 to 12.32, the changing current and other conditions being the same: At 12.34 this armature was immersed in another bath of about 43200 c.c. H2O and raised its temp: allowing for heat of room 11°F (74° − 85°) = $\frac{1752000}{9}$ H.U.

So that while the voltage of no 2 was 19% short of that given by no 1, the 25 Heat units of heat was 14400 units against 26400 units in no 1 or 45.5% short and the mean still has heat generated by

copy [illegible]

Clock + Watch Rates

Date	Clock Error	Difference	Days.	Rate.	Pos of Winding	Days of repairs			Watch error	Diffce	Days.	Rate
25. 6. 88	0				9 am.				20 −			
26. 6. 88	6.75+	6.75+	1	6.75+					42 −	8 +	1	8+
27. 6. 88	8.6+	0.15+	3	0.05+	9.0							
28. 7. 88	21.4+	13.3+	3	4.4+	Noon							
29. 7. 88	23.3+	6. +	4	1.5+	Noon							
30. 7. 88	26.2+	1.7 −	1	1.7 −								
31. 7. 88	20. +	6.2 −	3	2.07 −								
11. 7. 88	17. +	3. −	1	3.0 −								
12. 7. 88	34.2+	17.2+	1	17.2+								
14. 7. 88	36.5+	5.3+	2	2.65+								
18. 7. 88	42.0+	5.5+	4	1.4+								
19. 7. 88	47.75+	1.75+	1	1.75+								
23. 7. 88	49.0+	5.25+	4	1.68+								
24. 7. 88	49.4+	0.5+	1	0.5+								
25. 7. 88	51.5+	2.1+	1	1.5+								
27. 7. 88	19.5+	−32										
29. 7. 88	56.4+	2.0+	2	1.0+								
31. 7. 88	60.5+	4.1+	2	2.05+								
2. 8. 88	61.5+	7.5	3	1.5+								
3. 8. 88	63.3+	2.0	1	2.0+								
4. 8. 88	66.25	2.75	1	2.75+								
9. 8. 88	63.5	−2.75										
11. 8. 88	74.	10.5	9	1.2+								
14. 8. 88	80	6	3	2.0+								
22. 8. 88	98.2	18.2	8	2.3+								
23. 8. 88	99.2	1	1	1								
25. 8. 88	96.2	−3	3	−1								

Particulars of Robert Brewster Cells

Cell no 1. has done most work, + consumed most

Cell	Weight of Zinc before	Weight of Zinc after	Loss. grammes	Joules Externally	Joules Internally	Ratio	Total Joules	Joules per gramme
1	3628	2328	1300	5026700	177370	28.34	5204070	3975
2	3628	3084	544	3574800	293630	12.17	3868430	6570
3	3628	3112	516	3543800	292480	12.12	3835980	7434

Cell	Weight zinc before	Weight of Zinc after	Loss	Joules Externally	Joules Internally	Ratio	Total Joules	Joules per gramme
Cells 1 2 3	3628	2840	788	4051700	254490	16 6.28%	4,306,190	5460

Tried following experiment with a phonograph motor ring of single winding. One bedplate received four pair of magnet cores of cast iron. Their diameters were 1.5" 2" 2.5" + 3" respectively). These couples were set in succession at the same point 90° apart and the ring was spun by a motor. Currents of known strengths were supplied to the coils of the two cores to follow.

Coils used	Speed observed	Speed required	Observed P.D. Deflect	Corrected P.D. Deflect	Speed observed	Speed required	Observed P.D. Deflect	Corrected P.D. Deflect
1.5"	1161	1350	110	12.8	1638	1350	214	176.3
2."	1281	1350	128	128.8	1422	1350	243	230.7
2.5"	1286	1350	120	135.5	1368	1350	225	222
3."	1602	1350	115	97	1188	1350	165	187.5

Connected the four sets of cores in succession at a definite distance, and connected a wire to pass between the poles with the ballistic galvr.

Cores	Current	Current	Throw Rel. Outer.	Mean	Ratio	Current	Throw	Mean	Ratio
1½	18°30'	2·5	23		1½	6	32·25	34·38	1
	18°45'		24	24			34·5		
	19°30'		23·25						
2	18°25'	2·5	29·5			6	53	53·3	1·55
	18°25'		30	30			53·5		
	18°30'		31						
2½	18°25'	2·5	27			6	61·5	62·5	1·81
	18°25'		27	26·67			63·5		
	18°25'		26				63·5		
3	18°25'	2·5	29·5			6	65	65	1·90
	18°25'		29·5	29·63			65		
			29						

Monday 25th June

Meters set to work at 9.30 through 70.

Thursday 28th June.

6 Watch cases arrived from the non-mag H.C. and also a winder.
Took the errors of the watches after winding them up and setting them approximately to time by the clock. 13.28 o'clock T. 70°F

1.	2	3	4	5	6	7	8	9	10	11
-17	+34	+77	-19	-12½	-46½	+94	+139	+27	-65	+56½

all watches left under glass stands in case dial up

Friday 29th June.

8.40 o'clock T. 62°F

1	2	3	4	5	6	7	8	9	10	11
-20	+28	+74	+34½	+12½	+26	-39½	-30½	+46	+86½	+51½

Found nos 4 5 6 7 +8 stopped. Reset them.

Refrigerator + hot-box arrived.

Compared Voltmeters as follows:—
Mains connected thro: 10000 ω, 100 ω of ratio coil being taken to potentiometer circuit.

Ayrton Perry 130 Voltmeter Error 0.2 — at 120
" " " 150 " " 2.2 — at 120
Temp. 19°. C.

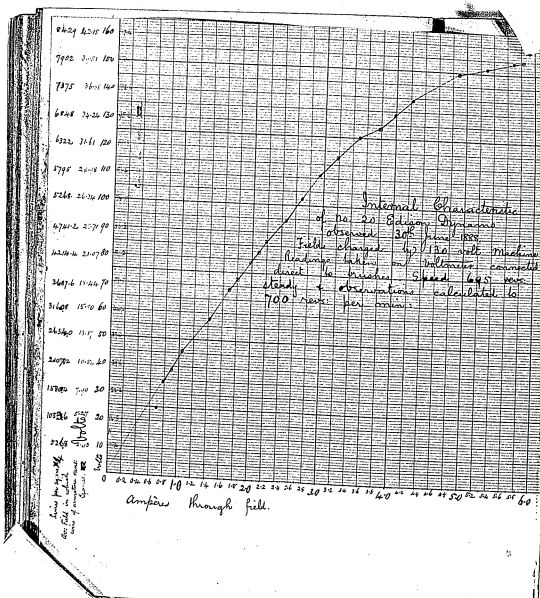
Connected chemical room with Dynamo room current through leads in main circuit giving 150 ampere (circa).

Watch errors Saturday 30th June. 8.40 o'clock dial up T. 64°

1	2	3	4	5	6	7	8	9	10	11
-22¾	+21	+19	+9	-24¾	+13½	-17½	-32	+69½	+1400	+44½
10½	-2¾	-7	-5					+25½	-48½	-7½

Took the errors of the ammeters as follow. (52)

Time of Obs.	Mach. Deflec.	Current from Mach.	15 Am. Reading	0 Amp. Reading	5 Am. Reading	Error	1 Amp Reading	Error
0	0	0	0.14	0.14 +	−0.01	−0.01	0.022	+0.022
5°.20'	0.025	0.131	0.5	0.374	0	−0.13	0.115	−0.016
5°.30'	0.039	0.204	0.5	0.30 +	0.	−0.20	0.175	−0.03
5°.5'	0.060	0.314	0.5	0.19 +	0.05	−0.24	0.298	−0.02
5°.10'	0.079	0.414	0.5	0.08 +	0.1	−0.31	0.394	−0.02
5°.20'	0.100	0.524	0.5	0.02 −	0.25	−0.27	0.487	−0.04
5°.35'	0.120	0.628	0.5	0.03 −	0.5	−0.13	0.578	−0.06
5°.35'	0.143	0.749	0.7	0.05 −	0.62	−0.13	0.715	−0.03
6°.5'	0.158	0.827	0.8	0.03 −	0.68	−0.15	0.785	−0.04
6°.50'	0.170	0.890	0.9	0.01 +	0.715	−0.17	0.840	−0.05
7°.45'	0.196	1.026	1.0	0.03 −	0.9	−0.13	0.975	−0.05
8°.17'	0.398	2.084	2.1	0.02 −	1.93	−0.15		
22°.2'	0.585	3.063	3.03	0.03 −	2.92	−0.14		
28°.40'	0.766	4.010	4.00	0.01 −	3.77	−0.23		
34°.20'	0.953	4.990	5.10	0.11 +	4.57	−0.42		
39°.20'	1.139	5.963	6.25	0.29 +				
43°.35'	1.313	6.874	7.2	0.33 +				
47°.30	1.490	7.801	8.35	0.55 +				
50°.45	1.680	8.796	9.2	0.40 +				
53°.45	1.870	9.791	10.1	0.30 +				
56°.40'	2.070	10.84	11.1	0.26 +				
59°.15'	2.265	11.86	12.2	0.34 +				
64°.40'	2.87	15.03	14.0	1.0 −				
65°.10'	2.93	15.34	15.3	0.04 −				



Saturday 30th June.

Internal of the No. 20 Dynamo after it has the speed of 700 revs. per min.

Current in Field	Volts.					
	Non Observed	Accepted Current in Field	Volts by curve 82	Volts by 120 v. curve	Accepted Voltage	Voltage calc. this to 700 rev
	-	0·7	29	30	29·5	29·7
	-	0·79	33	35	34	34·2
	-	0·90	38	39	38·5	38·7
	-	1·04	46·5	46·5	46·5	46·8
	1·4 - 1·43	1·41	57	57·8	57·4	57·8
	1·7 - 1·72	1·68	67·4	69·1	68·3	68·8
	1·8 - 1·82	1·80	72	72·2	72·1	72·5
	2·0 - 2·02	1·98	78·8	77·8	78·3	78·9
	2·1 - 2·12	2·09	81·6	82·1	81·9	82·5
	2·2 - 2·22	2·19	85·3	86·2	85·8	86·4
	2·45 - 2·47	2·444	92·6	94·6	93·6	94·2
	2·7 - 2·72	2·69	100·5	102·4	101·5	102·2
	2·95 - 2·97	2·94	110·5	110·0	110·3	111·0
	3·2 - 3·22	3·19	116·5	116·0	116·6	117·4
	3·5 - 3·52	3·49	123·0	123·2	124·2	125·0
	3·8 - 3·81	3·79	127·2	128·2	127·7	128·5
	3·95 - 3·97	3·98	132·4	132·6	132·9	133·8
	4·2 - 4·22	4·22	5	136·0	138·2	139·1
	4·50	4·89		146·0	147·2	149·2
	5·5	5·31		155·5	158·7	151·7
	6·0	5·71		158·0	158·2	154·2
	6·1	5·81		161·5	153·7	154·7

Saturday 30th June.

Took characteristic of the No. 20 Dynamo after Worked out to the speed of 700 revs. per min.

Speed	Current in Field					Volts.			
Speed.	H+B Ammeter	H+B Ammeter	H+B Ammeter	Accepted Current in Field	Volts by Accel 120	Volts by 120 revs Accepted	Accepted Voltage	Voltage calculated to 700 rev
6.45	0.65	0.70	–	–	0.7	29	30.	29.8
11.30	0.75	0.79	–	–	0.79	33	35	34.2
	0.85	0.90	–	–	0.90	38	39	38.7
	1.0	1.05	0.9-1.05	–	1.04	44.5	46.5	45.8
			1.25	1.30	1.25-1.30	1.41	57	57.8	57.4	57.8
			1.5	1.61	1.7. 1.72	1.68	67.4	69.1	68.3.	68.8
6.45			1.64	1.75	1.8 1.82	1.80.	72	72.2	72.1	72.5
7.45			1.8	1.95	2.0 2.02	1.98	78.8	77.8	78.3	78.9
			1.9	2.05	2.1 2.12	2.09	81.6	82.1	81.9.	82.5
			2.0	2.15	2.2 2.22	2.19	85.3	86.2	85.8	86.4
			2.25	2.40	2.45 2.47	2.44	92.6	94.6.	93.6	94.2
			2.5	2.65	2.7 2.72	2.69	100.5	102.4	101.5	102.2
			2.75	2.90	2.95 2.97	2.94	110.5	110.0	110.3	111.0
			3.0	3.15	3.2 3.22	3.19	118	116 117.0	116	116.6	117.4
			3.25	3.45	3.5 . 3.52	3.49	123.0	123.2	123	123.0	124.2	125.0
			3.5	3.75	3.8 3.81	3.79	127.2	127.2	128	128.2	127.7	128.5
			3.75	3.90	3.95 3.97	3.98	132.4	132.6	131	133.3	132.9	133.8
6.45			4.0	4.22	4.2 4.22	4.22			136.0	138.2	138.2	139.1
12.10.			4.4		5.0 4.89	4.89			146.0	148.2	148.2	149.2
			5.5		5.5 5.31	5.31			158.5	158.2	158.2	157.7
			6.0		6.0 5.71	5.71			168.0	163.2	158.2	154.2
			6.1		6.1 5.81	5.81			167.5	153.7	153.7	154.7

Investigation of the Magnetism of No. 20 Machine from the preceding Curve.

The length of the no 20 drum is 24.5" = 62.2cm. There are 50 blocks in the contr. each holding 3 wires making 1 turn amounting to 1172 feet in all. This wire is #5 BWG and has a res: of 0.000213 per foot. One sixth of 1172 is 195.3 = the length of each effective wire, and being in multiple one sixth of this is 32.55 which is the equivalent length of the armature this × 2.13 × 10^{4} = 6.93 × 10^{-3} = 0.006 ohm the actual res: being stated at 0.0072. The effective length for voltage is thus 50 half turns of the drum on each side. There will thus be 50 × 62.3 or 3110 cms of active wire. The mean diam. of the drum is 13.1" at the wire a circumference of 33.27 × π = 104.5 cms. A velocity of 700 revs per min = 11.667 turns per sec: = a circumferential velocity of 11.667 × 104.5 = 1220 and the differential of the area described by the wire is 1220 × 3110 = 3,792,000 sq. cms. The average field to produce one volt is thus $\frac{1.0 \times 10^{8}}{3.792 \times 10^{6}}$ = 26.37 Lines or 0.2634 Gauss.

The diameter of the hollow polar cylinder is 14" = 35.56 cms. a circumference of 111.7 cms = 55.85 cms for each pole but from this 5½" or 14 cms have to be taken for polar separation leaving 41.9 cms as the length of the polar surface. The breadth is 24.75" = 62.85 cms so that the polar surface is 62.85 × 41.9 = 2633 sq. cms

and the average number of lines passing through it is $\frac{3251.5}{2633} \times 26.35 = 3250$ per volt per sq. cm.

The average number of lines of force passing through the armature per sq. cm. per volt being $26.34 = 52.27 \times 62.2 \times 26.34 = 85{,}650$ per volt. the armature half surface being 3251.5 sq. cms. The diameter of the magnet core is $15.125'' = 38.42$ cms. and the area is thus 1158 sq. cms. The total no of lines of force being 85,650 per volt, the induction per volt in the core is $\frac{85{,}650}{1158}$ $= 73.99$ say 74 lines per sq. cm.

The wire on the core is No. 11 B.&S. 0.091 diam. having a res: of 11ω. This wire has a resistance of 0.001247 ω per foot so that $11\omega = 8.82 \times 11 = 97.02$ feet $= 29.57$ cms. The length of core being 23" = 60 cms and the number of turns to the layer about 220. The mean turn = about 40 cms so that the no: of layers $= \frac{29.57 \times 10^5}{\pi \times 2.20 \times 4.07 \times 10^5 \pi} = \frac{33}{\pi}$ and the total number of turns $33 \times 220 = 726 \div \pi = 2310$

According therefore to Kapp's Formula the induced

$$= \frac{2360 \times 2310\ A}{\frac{1440}{2633} \times 1.9 + \frac{18}{2500} + \frac{220}{1160}} = \frac{5{,}450{,}000\ A}{1.039 + 0.0073 + 0.19}$$

$$\doteq \frac{5.45\ A \times 10^6}{1.237} = 4{,}420{,}000\ A.$$

1 Ampere actually produced 44 volts

$= 44 \times 85{,}660 = 3{,}770{,}000$

Sunday 1st July

The watch data at 10 o'clock were as follows
Temp: 70°. No 7 under repair was 4s but stopped at 7½
Dial up. " 8 " " 5·10
Reversed next these and wound all others.

No 1	2	3	4	5	6	7	8	9	10	11
-24½	+12·5	+53	-51	-68½	+56½		+47	+92	-39·5	+30·5
-1½	-8½	-16		-41	+43			+22½	-19½	-6

N.	Date	1 Error	Ratio	2 Error	Ratio	3 Error	Ratio	4 Error	Ratio	5 Error
1	8.25/28.8	-17		+34		+77		-19		-12.5
2	8.24/29.6	-20	-4	+28	-7	+74	-4	+34.5	[illegible]	+12.5
3	8.24/30.6	-22.5	-2.5	+21	-7	+69	-5	9	[illegible]	-24.5
4	8.18/1.7	-20.5	-1.5	+12.5	-8.5	+59	-10	-57	[illegible]	-65.5
5	8.20/2.7	-26	-1.5	+2.5	-8.5	+39	-15	-117.5	+33.5	-99
6	8.20/3.7	-28	-2	-3	-6.5	+23	-15	+93	+27.5	-131
7	8.20/4.7	-28.5	-.5	-7.5	-5.5	+9	-14	+42	+32.5	-171.5
8	8.20/5.7	-29	-.5	-11.5	-4	-26	-35	+149.5	+27.5	-203.5
9	8.20/6.7	-27.5	+1.5	-19	-7.5	-42.5	-16.5	+85	+35.5	-238.5
10	8.20/7.7	-33.5	-6	-24	-5	-57.5	-15	+120.5	+29.5	-276
11	8.20/8.7	-37	-3.5	-32.5	-8.5	-96	-38.5	+237.5	+25.5	-305
12	8.20/9.7	-32	+5	-44	-11.5	-98.5	-2.5	+249.5	+12	-340
13	9.8/10.7	-33	-1	-56	-12	-145.5	-47	+344	+34.5	-381
14	9.8/11.7	-30	+3	-65.5	-9.5	-164	-18.5	+463	+19	-407.5
15	9.25/11.7	-33.5	-3.5	-66.5	-1.5	-114.5	+49.5	+444	-19	-407.5
16	9.25/12.7	-35.5	-2	-67.5	-1	-98.5	+16	+477.5	+12.5	-427.5
17	9.25/13.7	-47	-11.5	-69	-1.5	-76	+22.5	+573.5	+25.5	-455.5
18	10/14.7	-40	+7	-82	-13	-113.5	-37.5	+555.5	+32.5	-500
19	8/21.7	-30.5	+9.5	-91	-12	-167	-53.5	+582	+26.5	-577
20	9/22.7	-21	+9.5	-103	-9	-222	-55	+610.5	+28.5	-604.5
21	8.15/23.7	-12	+9	-114.5	-11.5	-238.5	-16.5	+638	+27.5	-658.5
22	8.16/24.7	-2	+10	-128.5	-13.5	-280.5	-42.5	+658.5	+15.5	-689
23	8.20/25.7	+10.5	+12.5	-138.5	-10	-339	-58.5	+694	+30.5	-737.5
24	8.25/26.7	+19	+8.5	-146.5	-8	-342.5	-3.5	+696.5	+2.5	-766.5
25	9/05/27.7	+27	+8	-153.5	-7	-348.5	-6	+716.5	+20.5	-801.5
26	8.25/28.7	+35	+8	-160	-6.5	-353.5	-7.5	+742.5	+26	-836
27	8.20/29.7	+35.5	+0.5	-159.5	+.5	-328.5	+25	+755	+12.5	-874.5
28	8.20/30.7	+38	+2.5	-157	+2.5	-305	+23.5	+764.5	+9.5	-913
29	8.20/31.7	+40.5	+2.5	-159	-1	-291.5	+13.5	+21	+20	-949.5
30	8.20/32.7	+41.5	+.5	-161	-2	-278	+13.5	+776.5	+12.5	-985
31	8.20/33.7	+43	+1.5	-161	0	-250	+28	+793	+16.5	-1021.5
32	10/03/34.7	+44.5	+1	-162	-1	-227.5	+22.5	+60	+15.5	-1058
33	8.20/35.7	+46	+2	-164	-2	-194.5	+33.5	+825.5	+25.5	-1103.5
34	8.20/36.7	+57	+11	-177	-13	-214	-19.5	+110	+26.5	-1142.5
35	8.20/37.7	+60	+3	-180.5	-3.5	-187.5	+26.5	+119	+9	-1179
36	8.20/38.7	+75	+15	-193	-12.5	-158	+29.5			-1222.5
37	8.15/39.7	+80	+5	-202	-9	-150	+8			-1244.5
38	8.15/40.7	+83.5	+3.5	-210	-8	-98	+52	-23		-1300
39	8.20/41.7	+88.5	+5	-215	-5	-87	+11	+195		-1325
40	8.15/42.7	+94	+5.5	-219	-4	-115	-26	+240		-1358

N.	6 Error	Ratio	7 Error	Ratio	8 Error	Ratio	9 Error	Ratio	10 Error	Ratio	11 Error	Ratio	N.
1	-46.5		+9.5		+139		+27		-65		+56.5		1
2	+4.5	51.5	-36.5	45.5	-30	169	+46	181	+85.5		+57.5	-6	2
3	+12.5	41.5	-45.5	9	-32.5	-1.5	+69.5	+23.5	-85.5	-14.5	+54.5	-7.5	3
4	+57.5	+45	-45.5	-.5	+147	174.5	+92	22.5	-57.5	-14.5	+38.5	-6	4
5	-22	34.5	-45.5	0	+107.5	54.5	+116	+24	-76.5	-19.5	+33.5	-5.5	5
6	+2	+24	+34	+17	-8	+4	+137.5	+22.5	-94	-17.5	+29	-4.5	6
7	+30.5	+10.5	+65.5	+31.5	-14.5	+6.5	+164.5	+27.5	-113.5	+19.5	+27	-2	7
8	-71.5	-32.5	+124.5	+59.5	+117	131.5	+169	+5	-131.5	-18	+18	-9	8
9	-80.5	-9.5	+154	+31.5	+109	+2	+194.5	+25.5	-149.5	-18.5	+12.5	-5.5	9
10	-101	-20.5	+209	+55	+100	-9	+217	+22.5	-169.5	-20.5	-11.5	-23	10
11	-146.5	-45.5	+246.5	+38	+82.5	-17.5	+219	+2	-186.5	-17	-22.5	-11	11
12	-172.5	-26	+267	+21	+81.5	+1.5	+237	+18	-202.5	-16	-24	-3.5	12
13	-206	-33.5	+310	+43	+80	-1.5	+252	+15	-220.5	-18	-52	-28	13
14	-238.5	-32.5	+344.5	+34	+74	-6	+251	+1	-237.5	-17	-65	-13	14
15	-261	-22.5	+385.5	+41.5	+66.5	-7.5	[illegible]	[illegible]	-256.5	-19	-72	-7	15
16	-279.5	-18.5	+411.5	+26	+55.5	-11	-1.5	+26	-273.5	-17	-72	-10	16
17	-304.5	-25	+438.5	+27	+39.5	-15.5	+21.5	+20	-292.5	-19	-100.5	-28.5	17
18	-347	-42.5	+461.5	+23	+44.5	+5.5	-20.5	-1.5	-309.5	-17	-109.5	-9	18
19	-371	-24	+485.5	+24	+44.5	+.5	+16.5	+7	-323.5	-14	-115	-5.5	19
20	-368	-17	+515.5	+27.5	+59.5	+15	+6	+15.5	-343.5	-20	-121.5	-6.5	20
21	-387.5	-19.5	+534.5	+20	+47	-12.5	+7.5	+1.5	-359.5	-16	-122.5	-1	21
22	-407	-19.5	+573.5	+39	+45	-2	+82.5	+75	-376.5	-17	-134	-8.5	22
23	-431.5	-24.5	+595	+21.5	+49	+4	+90.5	+8	-393.5	-17	-126	+10	23
24	-471.5	-40	+619.5	+24.5	+49	+0	[illegible]	[illegible]	-410.5	-17	-142.5	-16.5	24
25	-506.5	-35	+644	+24.5	+50.5	+1.5	-16	[illegible]	-426.5	-16	-145.5	-3	25
26	-545	-38.5	+668.5	+24.5	+46.5	-4	+2	+18	-444.5	-18	-152	-6.5	26
27	-587	-42	+694.5	+26	+40.5	-6	+25.5	+23.5	-464.5	-20			27
28	-629.5	-42.5	+720.5	+26	+30.5	-10	+50.5	+25	-479.5	-15			28
29	-673	-43.5	+745.5	+25	+24.5	-6	-16	[illegible]	-494.5	-15			29
30	-717.5	-44.5	+770.5	+25	+21	-3.5	+09	[illegible]	-509.5	-15			30
31	-762.5	-45	+795.5	+25	+17.5	-3.5		[illegible]	-524.5	-15			31
32	-807.5	-45	+821	+25.5	+17.5	0		[illegible]	-539.5	-15			32
33	-852.5	-45	+846.5	+25.5	+23	+5.5	-12.5		-554.5	-15			33
34	-897.5	-45	+872.5	+27	-10.5	-8.5	+10.5		-569.5	-15			34
35	-942.5	-45	+898	+25.5	-10	+.5	+16.5		-584.5	-15			35
36	-987.5	-45	+923.5	+25.5	-11	-1	+16		-599.5	-15			36
37	-1032.5	-45	+949.5	+26	-9	+2	+28.5		-614.5	-15			37
38	-1077.5	-45	+975	+25.5	-7.5	+1.5			-629.5	-15			38
39	-1122.5	-45	+1000.5	+25.5	-7	+.5			-644.5	-15			39
40	-1167.5	-45	+1026	+25.5	-6.5	+.5			-659.5	-15			40

* Probably due to [illegible] minutes [illegible] [illegible]

* Perhaps [illegible] down

Res: of Magnet 5.020

Throws from 1 standard cell 19.5°C. through 0.5Ω

136
133.75
136.9
135.3
Mean 134.99 EMF 1.4333

Temp. of room 68.9°F. = 20.5°C.

After observations

Throws from 1 standard cell 21.5°C.

135.0
135.0
135.8
135.9
Mean 135.43 EMF 1.4308

$$\mathcal{L} = \frac{d \times 0.71597 65 \times 5235 \times 10^{8}}{135.24 \times 46.57}$$

Time	Volts	Ohms.	Bring after 1 min.	Ambient temp.	Throw	Corrected	Adjusted Mean	$\mathcal{L}$
3.20	116.9	—	Initial 0.1	190.5	2.0	2.0		
.24	117		- - -		2.6 ?	2.67	1.92	114.3
.36	117		- - -		1.5	1.5		
.44	117.2		- 0.21	381	3.9 ?	3.71?		
.51	117.1		- 0.205		3. ?	2.93?	3.61	214.8
.55	117.1		- 0.21		4.21	3.902		
.59	117.2		- 0.14	762	9.25	9.25		
4.08	116.5		- 0.14		9.5 ?	9.5?	9.2	5275
.11	117.2		- 0.14		9.0	9.0		
.21	116.9	136	0.136609	1905	22.	22.1		
.29	117.1		0.136609		23	23.1	22.55	12444
.33	116.7		0.136609		22.4 ?	22.5?		
15.00	116.	76.65	0.2287 97	2857	33.8 ?	33.8 ?		
.06	115		0.2287 97		33.1	33.4	33.8	2011
.16	116		0.2287 97		34.	34.2		
.21	116.2		0.2287 97					
.26	116.3	43.88	0.3461 09	4762	54.6	54.7		
.31	116.5		0.34270		54	53.4	54.7	3255
.35	116.0		0.35783		54.9	55.5		
.42	116.7	37.43	0.40911	5733	62.7	62.85		
.46	117.0		0.40911		62.8	62.95	62.88	3741
.50	117.1		0.40911		62.9	62.95		
.55	116.9	26.44	0.52672	7620	73.9 ?	73.3 ?		
16.00	115.6		0.52672		79	78.3 ?	78.29	4471
.03	112.3		0.53332		80.3 ?	81.71 ?		
.07	116.1		0.58672		78.1	78.1		
.13	116.2	20.44	0.68321	9225	91	91.05		
.16	116.4		0.68321		90	90.05	90.46	5383
.19	115.5		0.68321		90 ?	90.05 ?		
.25	117.7	—	0.82490	11488	98.5 ?	99.3 ?		
.31	116.9		0.81703		99.1	98.5	98.43	5858
.34	116.2		0.81703		98 ?	98.4 ?		
.38	112	14.15	0.93252	13285	103.2 ?	105.7 ?		
.41	115.3		0.93252		102.9	103.2	103.66	6169
.58	116.2		0.96098		102.5	103.1		
17.01	116.1	11.85	2.7.35	15240	105.4	105.3		
.05	115.9		2.7.35		105.2	105.7	105.4	6451
.10	115.8		2.7.35		105.	105.2		
.16	115.2	9.607	50°.45'	17145	111.9	112.5		
.24	117.1		50°.00'		111.3	110.9	111.62	6643
.30	115.1		50°.45'		110.7 ?	111.5 ?		
.38	115.0		53°.50'	19050	114.4	114.3		
.41	115.5		53°.45'		113.6	113.9	114.03	6786
.44	115.3		53°.50'		114.0	113.9		

Tuesday 3rd July.

Calculation of the nett cost of producing Zinc sulphate

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$
$$65 + 98 = 161 + 2$$

∴ 65 grammes of Zn } form 161 of $ZnSO_4$
98 - - H_2SO_4 }

At the density of 1.0554, 100 grammes of ~~solution~~ contain 5.2 grammes of pure $ZnSO_4$ (anh.)

100 c.c. of solution weigh 105.4 grammes
∴ 100 . . . . contain 5.2 × 1.0554 grammes $ZnSO_4$
- 5.48 grammes pure anh. . .

1 gallon contains 4541 c.c. or 4541 × 5.48 . .
= 24.88 kg grammes pure $ZnSO_4$
= 0.5488 lbs.

161 grammes of Zinc require 65 of Zn = 98 of pure H_2SO_4
1 - - - - $\frac{65}{161}$ . . $\frac{98}{161}$ - - -
24.88 g. - - - . $\frac{65 \times 24.88 g}{161} = 100.5$ $\frac{98 \times 24.88 g}{161} = 151.6$

~~1 gallon~~
1 gallon contains 100.5 grammes of Zn and 151.6 grammes H_2SO_4
0.2215 lbs . . - 0.3342 lbs pure

1 lb. of Zinc requires 1 lb. of common Zn at 7½d per lb.
and 370 ampere hours of current at say 0.5 volt or
185 Watt hours = $\frac{1}{5}$ H.P. hours of electricity.
1 lb. of H_2SO_4 c.p. costs 12 c. actual or 15 cts here
1 H.P. hour costs 3 cts.

1 gallon contains 0.17 cents worth of current
2 cents worth of common Zinc
5 - - - H_2SO_4 pure.
0.5 - - - chemn, + reagents
7.67 -

The N.Y. price list gives 10 cts a gall for distilled water
+ 25 cts a lb for $ZnSO_4$ so that 2 gallon of
solution would be at this rate 10 + 0.5 × 25 = 23.8 cts
Things taken at 22c. cents per gall:
Prepared 8½ galls. of solution in carboy for Fall River Mass.

1 Standard cell @ 20.5°C 0.5t before obs:

135
135.9
135.6 ?
135.4

Mean 135.46 EMF 1.432

Mean temp. of room 22.4°C

1 Standard cell @ 23°.7C

136.3
135.8
135.0
136.1

Mean 135.8 EMF 1.428.

$$\mathcal{L} = \frac{d \times 0.715062 \times 5273 \times 10^3}{135.6 \times 46.57}$$

$$= 59.696\ d$$

Time	Volts	July 3rd Ohms	Lab.	Lockefeather dist Amperes turns	7.985 Ohms	Corrected	Mean	Co Lo
10.13	117.7	32 + 3pt	0.1	190.5	2.2	2.2	2.4	1143
.23	117.6		0.1		2.5	2.5		
.33	117.6		0.1		2.5	2.5		
.41	117	12 + 350	0.205	381	3.67	3.58?	4.13	2463
.45	116.9		0.2		4.0	4.0		
.52	116.9		0.2		5.8?	5.8?		
11.03	115.3		0.395	762	9.27	9.32?	9.04	5140
.07	114.3		0.392		9.1?	9.30?		
.12	115.7		0.40		8.5?	8.5?		
.22	116.3	105 x 10	7.50'	1905	23.4	23.2	22.6	13149
.27	116.5		7.50'		22.9	22.5		
.38	116.5		8.15'		20.2?	20.6?		
.44	117	78.89	11°.35'	2857	29.2	29.24	30.12	17799
.47	116.5		11°.35'		30.3	31.31		
.52	116.2		11°.35'		29.9	29.91		
12.21	115.9	57.09	15°.15'	3810	40	40.1	41.26	24163
.32	117		15°.15'		42?	42.1		
.41	107.3		14°.25'		39.5	42.0		
.47	116.2	44.72	18°.45'	4762	48	48.3	48.57	28999
.50	116.2		18°.45'		48.3	48.6		
.55	115.5		18°.45'		48.5	48.8		
14.07	116.5	26.35	22°.25'	5715	56.3	56.0	56.27	33591
.05	116.7		22°.25'		57.2	57.1		
.09	116.7		22°.25'		56.	55.7		
.22	118	27.23	28°.45'	7620	73	72.76	72.96	43355
.27	115.2		28°.40'		73.6	73.6		
.37	115.7		28°.40'		72.1?	72.1?		
.45	116.3	20.92	32°.15'	9525	83.8?	84.1?	83.84	50051
.52	115.6		32°.20'		83.7	83.76		
.58	115.8		32°.25'		84.	83.8		
15.06	115.7	17.38	39°.25'	11430	90	89.84	90.48	54402
.15	115.6		39°.30'		89.9	89.44		
.21	115.7		39°.20'		90.1?	90.11?		
.28	116.1		39°.25'		90.1	89.91		
.42	114.5	14.34	43°.15'	13335	96?	95.91?	96.71	5773
.49	114		43°.20'		97.8?	98.00?		
.56	114		43°.20'		95.9?	96.13?		
16.13	114.3		47°.50'		100.3	99.12	99.42	5735
.16	115.5	11.75	47°.40'	15240	100.9	100.51		
.19	114.0		47°.40'		98.9	98.42		
.26	115.9	9.4645	50°.40'	17145	106.3?	105.15?	104.09	6214
.30	113.6		50°.40'		103.1	103.64		
.34	114.0		51°.00		104.4	104.0		
.41	113.8	—	53°.20'	19050	107.5	107.4	107.52	6419
.50	113.8		53°.20'		107	106.9		
.58	114.1		53°.30'		107.8?	109.0?		

Wednesday 4th July

Two rubber covered wire completed to Engine Room. Insulation about 50Ω each and total res: including leads to first bottle about 4.92Ω

Thursday 5th July

Two glass tubes each 28 cm internal + 3.3 cm external diam, one 179.5 the other 174.5 cm. long were closed at their ends with plane glass disks cemented at the edge. About 9 cm from the ends, upright tubes about 1.5 cm in diam were blown into the main tubes, these were 23 or 24 cm. long and in the same plane. The solution employed was 10% H_2SO_4 in distilled water and about one litre was required to fill each.

Friday 6th July

Took down meters at 9.0. They had been at work since Monday 25th June 9.30. The current during that time has been on till about 23 o'clock except the 4th + 1st nights and one evening when current was reversed for 5 hours.

Tried the effect of the 120 volt dynamo on a dog – a fox terrier bitch. An alternator was first tried making 20 reversals per second, but owing to the screws in the instrument short circuiting the terminals, this failed. Therefore tried the direct current. The fore feet of the dog were lapped with damp cotton waste encircled with 2 or 3 turns of bare copper wire. The animal stood on the wooden engine room floor. On reaching an indicated potential of 1100 volts contact was made, for about 5 seconds. The animal writhed but uttered no yell till the contact was broken. Several fresh contacts killed it beyond question.

Weighed meter plates after washing them in distilled water and then drying by evaporation:—

Plate No.	Side	Weight 6.7.88	Joint weight 6.7.88	Weight 22.6.88	Joint weight	Gain	Loss	Diff. from Mean	% Error
1	~~B~~	22·6313	43·7222	21·2913	43·7062	~~0·2649~~	0·2084	0·0032	~~2·1%~~
2	~~B~~	21·2996	43·7219	22·4169	43·7062	0·2894	0·2084		
3	B	21·3367		21·1228			0·2139	0·0100	~~4·7%~~
4	A	21·8063	43·1438	22·0028	43·1276	0·2995			
5	A	21·4525	43·1430						
6	B	21·4764	42·9590	21·6859	42·9326	0·2278	0·2038	0·0002	0·09
7	A	21·4824	42·9595	21·2482	42·9329				
8	B	21·6566	43·1449	21·6872	43·1824	0·2289	0·1988	0·0051	~~2·5%~~
9	A	21·8671	43·1280	21·4277	43·1129				
10	B	20·6922	42·5588	22·0659	42·5332	0·2249	0·1988	0·0051	0·25
			42·5593	20·4673	42·5332				
11	C	20·5012	40·5783	20·2925	40·4863	0·2187	0·1960	0·0079	0·39
12	A	20·0072	40·5784	20·2032	40·4857				
13	C	21·7265	42·7600	21·5329	42·7356	0·2236	0·1985	0·0054	0·27
14	A	21·0038	42·7603	20·2030	42·7372				
15	A	21·1455		21·3636			0·2181	0·0122	0·56
16	B	21·3586	42·5043	21·1552	42·5194	0·2032			
			42·5061		42·5190				
17	C	20·9944	41·2212	20·7749	41·2087	0·2195	0·2089	0·0090	0·43
18	A	20·2266	41·2210	20·4355	41·2086				
19	B	22·1800		21·9550		0·2250			
20	A	20·1359	42·3162	20·3381	42·3331		0·2022	0·0017	0·08
			42·3169		42·3331				
						Mean	0·2039	0·006	~~2·9%~~

The red ink figures are the arithmetical means of each pair.
The mean error is thus 2·9%
These plates had not been fully amalgamated before this trial, and the large error is probably due to this.

Saturday 7th July

Took the Gauss magnetometer + apparatus with Llewellyn Park to determine H.

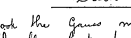
About 14·30 the silver watch was observed to be 18 secs slow by the clock.

Deflection observations as follow:—

Distance from mirror to scale 98·5" = 250·2 cm.

Torsion before observations $\frac{\pi}{2}$ clockwise 0·4 } 0·425
$\frac{\pi}{2}$ counter — 0·45

The mirror on the vibrating magnet is on the southwesting side.



Position of mag.	Mirror Magnet Towards	Deflection observed	Zero	Corrected Reading	a	b	c	d	a+b	a+b
a	in	+9·62		9·62	9·62				9·62	23·9
	out	−9·75	0·3+	19·05	−10·05				10·05	23·48
						Mean 23·69	Mean −23·445		9·75	23·8
d	in	−9·75		−9·75				−9·75	9·80	23·09
	out	+9·80	0·0	+9·80				+9·80	19·55	3·27
								Mean	9·805	23·59
b	out	−23·9		−23·9		−23·9				
c	in	−23·42	0·0	−23·8			−23·8			
c	out	+23·09		+23·09	Mean 9·775		+23·09			
b	in	+23·48	0·0	+23·48		+23·48		Mean 9·775		

Torsion after observations $\frac{\pi}{2}$ clockwise 0·45 } 0·435
$\frac{\pi}{2}$ counter do 0·42

Mean of all torsions 0·430.

Observed the period of the swinging magnet by four sets of observations as follows:

1st set swing 9.5 ±

No.	Transit		No.	Transit		No.	Transit		No.	Transit
0	16·8·31		44	14·17·8		141	76·26·5		187	45·42
1	8·45		45	·29		142	·13		188	·44
2	·56		46	·32		143	·29		189	·38
3	9·8		47	·44		144	·41		190	·30
4	·19		48	·55		145	·52		191	·57
5	·31		49	418·07		146	37·07		192	46·49
6	·43		50	·19		147	·15		193	·12
7	·55		51	·31		148	·29		194	·27
8	10·7		52	·43		149	·39		195	·34
9	·15		53	·56		150	·51		196	·39
10	·30		54	19·05		151	38·02		197	47·03
11	·43		55	·17		152	·14		198	·13
12	·56		56	·29		153	·26		199	·25
13	11·5		57	·41		154	·38		200	·36
14	·17		58	·52		155	·49		201	·48
15	·29		59	20·03		156	39·01		202	48·00
16	·40		60	·16		157	·13		203	·12
17	·52		61	·29		158	·24		204	·23
18	12·4		62	·40		159	·37		205	·36
19	·16		63	·51		160	·48		206	48·47
20	·27	Coefficient of 1/4 ″ = 2·87″ 2·37 ″ @ 11·8 2·23 ″ @ 11·8 224	64	21·03	Coefficient of 1/2 ″ = 9·02″ 7·67 ″ @ 11·72	161	·59	Coefficient of 3/4 ″ = 3·95″ 3·23 ″ = 9·93 ″ 24 ″ = 3·34 ″	207	

20 vibs in 236″ 11·8.

20 vibs in 235″ = 11·75.

20 vibs in 236″ = 11·70

64 vibs in 752 = 11·75.

161 in 1888 = 11·727

207 in 40′. 23″ = 2402·5″ = 11·720″ probably.

The correction for watch error 7″ in 18000 is 0·04″

= 2403·44″ = 11·724″.

Torsion obs: 8 ⅗ clockwise + 1·62 − 1·75 = −0·065 = −0·00
⅗ counter — 7 1·49 + 1·67 = +0·09 = +0·00
0 − 1·61 + 1·69 = +0·035

Mean 0·078 div.

Observations with 6 loaded magnet.
Temp 11.8°.5

No.	Transit				Transit
0	18·46			34	18·19·20
1	·5·21			35	
2	·5·47			36	20·11
3	–			37	20·36
4	–			38	21·03
5	~~7~~·30			39	21·28
6	·54			40	21·52
7	–			41	22·19
8	–			42	22·44
9	–			43	23·09
10	–			44	23·35
11	9·52			45	24·00
12	10·17			46	24·24
13	10·43			47	24·51
14	11·8			48	25·17
15	11·34			49	25·42
16	–			50	26·08
17	12·23			51	26·33
18	12·48			52	26·58
19	13·24			53	27·23
20	18·13·244			54	27·49

Lapse of 9 3.20.5" ÷ 25 = 13.01.
12.0 25.46 = 24.92
13.0 25.46 = 26.33

24 obs in 533·5
= 25·410
19 in 483
= 25·420
29 in 501 & 1 501
= 25·400

20 obs in 8' 29" = 509"
= 25·45

54 in 22'·53" = 1373" = 25·426"
50 · 24·17" = 1277 = 25·42

Taking 25·426 · Correction for watch error = 0·5" west
= 54 in 22·53·5 = 1373·5 = 25·435"

Torsion 0.	=	−6·33	+6·59		
		6·30	6·57		
	Mean	6·315	6·575	=	0·13 +
$\frac{\pi}{2}$ clockwise	=	+5·70	−10·0	=	2·15 − = 2·28
$\frac{\pi}{2}$ counter	=	+13·9	−8·5		
		+13·92	−8·7	=	2·06 + = 1·93
					Mean = 2·105

Scale distance = 72·75" = 184·8 error. Experiment ends at 18·32.

The mean time t' of one complete vib. of the loaded magnet being 25.426^s, the angle of torsion produced by $\frac{1}{2}$ is $\tan^{-1} \frac{2.105}{184.9}$ = log. 0.32225 − log. 184.9 = 2.26695 = 39′

$$\therefore t^2 = \frac{5439}{5400} \times (25.426)^2$$

log 25.426 = 1.405298
1.405298
· 5439 = 3.735591
6.546093
5400 = 3.732438
2.813655 = 651.2

$25.426^2 = 646.48$
$\times \frac{5439}{5400} = 651.15$

The mean time t' of one complete vib. of the unloaded magnet being 11.724^s, the angle of torsion produced by $\frac{1}{2}$ is $\tan^{-1} \frac{0.078}{184.8}$ = log 0.078 − log 184.8 = 2.89209 − 2.26639 = 2′

$$\therefore t^2 = \frac{5402}{5400} \times (11.724)^2$$

log 11.724 = 1.069098
1.069098
· 5402 = 3.732546
5.801644
· 5400 = 3.732432
3.138844 = 137.50

$(11.724)^2 = 137.452$
$\times \frac{5402}{5400} = 137.50$

The moment of inertia of the ring is 1087.3 so that the moment of inertia of the magnet is

$$\frac{137.5}{651.15 - 137.5} \times 1087.3$$

log 1087.3 = 3.036311
137.5 = 2.138328
5.174639
· 513.65 = 2.710673
= 291.06

$= 291.06$

By laboratory measurement the moment has been 287.

The time of oscillation being $\sqrt{137.5}$

$$MH = \frac{4\pi^2 \times 291.06}{137.5}$$

log π^2 = 0.994299
10 = 0.602060
· 291.6 = 2.464908
4.060448
· 137.5 = 2.138328
= 83.568

$= 83.568$

Accepting I at 287.0

$$= \frac{4\pi^2 \times 287}{137.5}$$

$4\pi^2$ = 1.596399
287 = 2.457882
4.054281
· 137.5 = 2.138328
= 82.40 1.918292

$= 82.402$

The corrected deflections are

$\frac{5400+v}{5400} \times 9.805$ and $\frac{5400+v}{5400} \times 23.57$

Where $v = \tan^{-1} \frac{0.43}{250.2} = \frac{2.3}{2.502} \times 10^{-3} = 1.719 \times 10^{-3} = 6'$

$\log .43 = \bar{1}.633247$
$-\ \log 2.502 = \bar{3}.398724$
$\bar{3}.235518 \quad .6'$

$\frac{5406}{5400} \times 9.805 = 9.8157$

$\log \frac{5406}{5400}$ 0.000484822
9.8157 0.991464776
0.992949598 pr.157

$\frac{5406}{5400} \times 23.57 = 23.596$

23.57 1.372339 6
0.000484822
1.372824818 23.596

$\tan^{-1} \frac{9.816}{250.2} = \log \frac{9.816}{250.2} =$ 0.991929 9
2.398287 3
2.603642 5
6006767
.0029658 177986 .56
31619 19823

$\sin = 2907'.15 = 193 = 0.040011 25$

$\tan^{-1} \frac{23.596}{250.2}$ $\log \frac{23.596}{250.2} = 1.372839 24 - 2.398287 3 = 2.974551 1 =$
$5^\circ 23' 15''$
$\sin = 8.972730 0$ $\frac{974 2 - 72}{13,500} \quad \frac{3272 \times 60}{13,500} = 20.14$

$\sin = 0.093891 1$

$x = 50$
$x_1 = 37.5$

$$P = \frac{\frac{1}{2}(50)^2 \times 0.040113 - \frac{1}{2}(37.5)^2 \times 0.09389}{25 \times 0.040113 - 18.75 \times 0.09389}$$

$$= \frac{62500 \times 0.040113 - 26,367 \times 0.093891}{} = \frac{2507.0625 - 2475.6266}{1.002825 - 1.760458} = \frac{21.4359}{-0.757763}$$

$= -28.3$

$$\frac{M}{H} = \frac{(50)^3}{2} \times 0.040113 \times \left(1 + \frac{28}{2500}\right)$$

$$= \frac{62,500 \times 0.040113 \times 2528}{2500}$$

$$= 25 \times 0.040113 \times 2528 = 2535.1$$

$$\frac{M}{H} = \frac{(37.5)^3}{2} \times 0.09389911 \times \frac{2528}{2500}\left(1 + \frac{28}{1400.3}\right)$$

$$26,367.2 \times 0.09389911 \times 1.0112 = 2525.2$$

---

log $\frac{M}{H}$ = 1.915929 2 log $\frac{M}{H}$ 1.922032 1

$\frac{M}{H}$ = 3.403120 5 — 3.403120 5

5.319904 97 — 5.325 1526

2.658952 48 = 456.09 — 2.662576 3 = 459.81

1.915929 2 — 1.922032 1

T 2.564044 4 = 0.1805 — T 2.592588 = 0.1817

but

Moment of magnet 456.6. ! probable T 26°C

it was 443.4 on 28th from T 29°C

460.6 - 30th April T 22°C

Monday 9th July

Found a short circuit in the left hand limit of the pendulum electromagnet. Between the 2nd & 3rd fingers from the bottom.

Set the 3 Roberts-Beaumont primary cells to work again through 0.5Ω but found that there was not enough solution left in the carboys to fill more than two properly, so that the third was run on less than half solution. These cells are numbered 1 2 & 3. No 2 is the efficient cell.

Also set the 3 Mason primary cells to work through 0.5Ω stranded platinoid wire. As one of these (No 4) had two carbons and a wider carbon head it is possible that it may have been short circuited by accident for has been below commencing. Numbers 4 5 & 6

The weight of the zinc plates in the cells were before starting.

No	Plate No.	Weights oz	grm	Plate No.	Weights oz	grm
1	1	56.13	1592	2	53.75	1524
2	3	55.13	1563	4	56.25	1595
3	5	53.20	1508	6	54.25	1538
4	5	82	2325	6	83.5	2367
5	2	82.25	2332	4	77.75	2204
6	1	81.5	2310	3	82.6	2341.2

The cells were set to work at 15.30

Tried the new Edison voltmeter. Found it to be very sensitive and to have a range of about 7 volts with 1 ampere traversing it.

(1)

Date	Hours	EMF	C	R.
15·30	97 0	2·180	4·016	0·044
16·00	" ½	2·121	2·528	0·101
16·30	" 2½	2·073	3·456	0·100
17·00	10·7 15½	2·034	3·538	0·072
17·30	" 28	2·025	3·572	0·064
18·00	11·7 43	2·009	3·574	0·058
18·30	" 53½	1·998	3·598	0·071
19·00	12·7 67½	1·956	3·600	0·068
19·30	" 76½	1·922	3·606	0·070
20·00	13·7 91	1·818	3·620	0·081
20·30	" 100½	1·706	2·932	0·081
21·00	14·7 115½	1·576	2·372	0·079
21·30	" 123	1·488	1·892	0·075
22·00	15·7 138½	0·966	0·820	0·068
22·30	" 172	0·446	0·796	0·069

Circuit broken

(2)

Date	Hours	EMF	C	R.
15·30	97 0	2·168	3·320	0·035
16·00	" ½	2·036	2·184	0·051
16·30	" 2½	2·027	1·806	0·0624
17·00	10·7 15½	2·025	1·230	1·142
17·30	" 28	2·015	1·425	0·913
18·00	11·7 43	1·982	1·578	0·7001
18·30	" 53½	1·830	1·664	0·673
19·00	12·7 67½	1·650	1·432	0·785
19·30	" 76½	1·422	1·564	0·746
20·00	13·7 91	1·316	1·476	0·798
20·30	" 100½	1·240	1·496	0·770
21·00	14·7 115½	1·186	1·484	0·770
21·30	" 123	1·038	1·476	0·745
22·00	15·7 138½	1·652	1·552	0·552
22·30	" 172	1·562	1·004	1·006

Circuit broken

(3)

Date	Hours	EMF	C	R.
15·30	97 0	2·180	3·360	0·113
16·00	" ½	2·128	2·480	0·115
16·30	" 2½	2·056	3·382	0·111
17·00	10·7 15½	2·034	3·492	0·072
17·30	" 28	2·020	3·524	0·070
18·00	11·7 43	2·027	3·576	0·076
18·30	" 53½	2·000	3·588	0·072
19·00	12·7 67½	1·980	3·596	0·079
19·30	" 76½	1·834	3·344	0·085
20·00	13·7 91	1·352	2·100	0·090
20·30	" 100½	1·733	2·980	0·056
21·00	14·7 115½	1·570	2·332	0·057
21·30	" 123	1·478	1·934	0·058
22·00	15·7 138½	0·860	0·816	0·088
22·30	" 172	0·441	0·788	0·086

Circuit broken

The total No. of Joules = 375,590
External 257,300
Total 632,890
607 Gramme-Zinc used =
= 4766 Joules per gm.

Internal Total Joules

Internal Total Joules

(4)

Date	Hours	EMF	C	R.
15·30	97 0	2·054	3·972	0·025
16·00	" ½	2·018	3·372	0·099
16·30	" 2½	2·020	3·426	0·090
17·00	10·7 15½	2·000	2·476	0·146
17·30	" 28	1·980	1·568	0·207
18·00	11·7 43	1·620	0·788	0·322
18·30	" 53½	0·910	0·720	0·069
19·00	12·7 67½	0·605	0·670	0·107
19·30	" 76½	0·598	0·640	0·1312
20·00	13·7 91	0·586	0·592	0·131
20·30	" 100½	0·576	0·580	0·143
21·00	14·7 115½	0·570	0·560	0·157
21·30	" 123	0·562	0·528	0·148
22·00	15·7 138½	0·556	0·5844	0·5833
22·30	" 172	0·510	0·496	0·529

Circuit broken

(5)

Date	Hours	EMF	C	R.
15·30	97 0	2·092	3·732	0·061
16·00	" ½	1·968	3·486	0·068
16·30	" 2½	1·949	3·406	0·072
17·00	10·7 15½	1·852	2·972	0·126
17·30	" 28	1·792	2·640	0·130
18·00	11·7 43	0·988	1·432	0·187
18·30	" 53½	0·676	0·896	0·244
19·00	12·7 67½	0·644	0·796	0·316
19·30	" 76½	0·572	0·688	0·331
20·00	13·7 91	0·521	0·624	0·306
20·30	" 100½	0·526	0·606	0·347
21·00	14·7 115½	0·526	0·588	0·346
21·30	" 123	0·510	0·520	0·379
22·00	15·7 138½	0·478	0·524	0·412
22·30	" 172	0·452	0·524	0·420

Circuit broken

(6)

Date	Hours	EMF	C	R.
15·30	97 0	2·101	3·824	0·121
16·00	" ½	2·0122	3·824	0·1141
16·30	" 2½	2·045	3·302	0·131
17·00	10·7 15½	1·890	3·112	0·107
17·30	" 28	1·746	2·704	0·133
18·00	11·7 43	1·322	1·332	0·3377
18·30	" 53½	0·722	0·828	0·376
19·00	12·7 67½	0·612	0·672	0·410
19·30	" 76½	0·570	0·632	0·433
20·00	13·7 91	0·555	0·594	0·439
20·30	" 100½	0·570	0·576	0·479
21·00	14·7 115½	0·570	0·558	0·521
21·30	" 123	0·566	0·560	0·511
22·00	15·7 138½	0·566	0·500	0·632
22·30	" 172	0·550	0·500	0·600

Circuit broken

(7)

Date	Hours	EMF	C	R.
15·30	97 0	2·054	3·972	0·025
16·00	" ½	2·018	3·372	0·099
16·30	" 2½	2·020	3·426	0·090
17·00	10·7 15½	2·000	2·476	0·146
17·30	" 28	1·980	1·568	0·207
18·00	11·7 43	1·620	0·788	0·322
18·30	" 53½	0·910	0·720	0·069
19·00	12·7 67½	0·605	0·670	0·107
19·30	" 76½	0·598	0·640	0·1312
20·00	13·7 91	0·586	0·592	0·131
20·30	" 100½	0·576	0·580	0·143
21·00	14·7 115½	0·570	0·560	0·157
21·30	" 123	0·562	0·528	0·148
22·00	15·7 138½	0·556	0·5844	0·5833
22·30	" 172	0·510	0·496	0·529

Circuit broken

Internal Total Joules
External -
178,860
493,300
672,160

546 grs Zn consumed
= 1232 Joules per gr.

Internal Total Joules
External -
202,460
730,100
932,560

524 grs Zn consumed
= 1780 Joules per gr.

Internal Total Joules
External -
257,900
705,700
963,600

521 grs Zn consumed
= 1850 Joules per gr.

Faulty pendulum limit recovered with inlet paper between the layers.

1st layer 199 turns
2nd " 194 "
3rd " 189 "
4th " 191 "
5th " 181 "
6th " 74 "

Total 1028. Previously 1057.

Res: = 2.469 Diam external over paper 10 cm.

Physiological effect of shock—

Two dogs for experiment.

1st Small black mongrel:

Parcelled one fore leg and the opposite hind leg with wet cotton waste wrapped with wire. Res: between these wires about 7500 by bridge.

800 volts from Municipal machine applied direct for about 2 sec to dog as it rested on rubber sheeting. Current commenced at 1/10 amp: ended at 1 amp:

22 beats. Result. fatal after some minutes.

2nd dog light tawny animal of greyhound extraction. Parcelled as above. Res: about 8500.

Direct current from 290 volts given for one second. 1/4 amp indicated current. Result not fatal. Dog not much hurt.

Current then alternated at same voltage 11 turns per sec: Contact made for 2 sec. Result not fatal but dog much debilitated for several mins:

Current then alternated 47 turns per sec at 800 volts pressure. Contact for 3 sec: Result fatal in less than half min.

Wednesday 11th July.

Raw Plating Dynamo at 11.45.
1090 revs per min = 28 feet per sec. EMF 4·6 volts

Thursday 12th July.

Tested 5 dynamo circuit which does not giving satisfactory results as follows. only 7 oz Wattsville of zinc per hour. on 15 cathodes

Res: of leads down to engine room plighboard 5·169 ω.

Res to the Chemical room junction with the 3 wire cable 5·182 or 0·013 ω

Res to the baths in the plating room at end of cable 5·190 or 0·021 or 0·008 ω in 3 wire cable

Res: including one bath 5·250 = 0·060 ω in one bath.

Current would be with 3 in series
4·5 ÷ 0·200 = 22·5 amperes.
actually 33 amperes were obtained.
The leads are 216 feet long from the plighboard to the junction with the cables in the chemical room. that is 432 feet of conductor (say 400 feet of it as the engine room part is of much larger area) made up of two rods ½" diam = 0·00004014 ω per foot
= 0·016 ω ÷ 2 = 0·008 ω

Physiological experiments.

Hands wiped dry and brought in contact with two terminals in connection with the municipal dynamo whose potential diff was deduced to be 1200 by voltmeter. Strong shock felt with muscular contractions in elbows and principally on breast. Diggy connection allied to syncope for the minute. Contact with terminals only momentary. Temporary debility lasting for a few minutes and headache followed. Two small blisters that if in doubt at point of contact the two small blisters that if in doubt at point of contact the point on the body just of the thumb right hand, — point on the outer edge of the pillow letter in the drafts.

Copper wire data.

1 mil foot is stated to be on Mathiessen's authority 9.718 B.A. ω @ 0°C

= 9.610 Legal ohms @ 0°C

= 10.527 " " @ 75°F or 18°C

@ 90% purity this becomes

11.7 " "

The diameter of the copper leads to the Chemical building is 0.635 so that its circular mils are 403,225.

$11.7 \div 403225 = 11.7 \div 4.03 \times 10^5 = 2.90 \times 10^{-5}$ per foot

$= 1.45 \times 10^{18}$ per foot 2 together + there are about 400 feet. $580 = 5.80 \times 10^{-3} = 0.0058\omega$

There are about 80 feet of cable 160 in all of 3 wires each 0.203 or 412,1000 c. mils $= 2.83 \times 10^{-10}$

$= 0.000283$ or 0.000009ω per foot jointly

$= 9.4 \times 10^{-10} \times 160 = 0.00\cancel{1}4$

The res: in cct: should be in Dynamo connection 0.001

Leads to Chemical room 0.008

" beyond 0.007

0.011

3 baths in multiple 0.015

0.026

= 200 amperes

3 baths in series 0.135

= 30 amperes

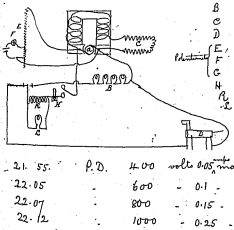
Physiological Experiments. 12th July

Before Mr H. P. Brown & in the presence of Dr Peterson nerve specialist of the Vanderbilt Clinic Hospital.

Dog no 3. Fox terrier bitch
Length tip of nose to base of tail 24"
Height 13"
Weight 13½ lbs.
Resistance 6000 – (about)

Wet cotton waste bandages were applied in the ordinary way to the opposite fore & hind legs. (rt fore & left hind) These were wrapped over with copper wire.

Connections as follow—



a Municipal armature
B lamp bank of 12 lamps
C Controlling field rh.
D Dog
E, F Electrodes { E, fore – Cathode. F – hind – Anode
G Daylight cell or cells
H Ammeter.
R Phelps relay
L 32 cp. lamp shunt.

21. 55. P.D. 400 volts 0.05 amp momentary direct current, not fatal
22.05 – 600 – 0.1 – – – – – –
22.07 – 800 – 0.15 – – – – – –
22.12 – 1000 – 0.25 – – – – – –

1000 volt momentary current fatal in 2 mins.

Dr Peterson then dissected. The animal's heart continued to beat until 22.50 when it was cut out. The muscles also were in automatic twitching for a considerable time. He removed parts of the sciatic and nerves also part of the cords spinal cord for microscopic examination.

2nd bird. Dog no 4.
Half bred. bull dog
Length tip of nose to base of tail 37"
Height 21"
Weight 46½ lbs.
Res: 11,000 ω

Alternated current 2200 times per min = 36·7 per
23.22. 800 volts Current in amperes 0·1 amperes Contact
2½ secs. Result fatal in 15 secs.

Res: of Mr Brown @ follows
(1) Standing on brass plate as one electrode on dry floor and holding a brass connecting screw in his dry hand as the other electrode. Res Z 180,000 ω.
(2) Hands moistened and plate wet, but boots still dry Z 178,000.
(3) Bare right foot on wet plate, sitting position + right hand holding wet towel compressing binding screw
Z 7320
C more say 7500.
(4) A terminal in each hand held in wet towels. Z } 19,090 ω
C }
(5) Wet towels and terminals on backs of hands under pressure of knees
Z 15,500
C less.

My own res: between hands, holding terminals in wet towels like (no 3) above
Z 5580 ω
measured by Mr Brown

1 Standard cell @ 21.9°c through 0.5 t

136.1
137.7 ?
136.6 ?
137.0 ?
136.7

EMF 1.430

Mean temp. of room 23.5°c.

After observations

136.3
136.8
136.3
137.1
136.7

@ 25.9°c = 1.426

$$L = \frac{d \times 0.71465 \times 5294 \times 10^{-6}}{136.25 \times 46.57} = 59.626$$

Time	Volts	Interpolation Phase	Dist Ind. C.	20 mm Magnet Amplitude	11.h Phase	Polar 33 Corrected	Means	L
10.25	115.7		0.0995	187.6	5.9	5°.93	6.072	362
.33	116.6		0.10		6.3	6.00		
.42	116.2		0.10		6.55	6.50?		
.53	118.2		0.201	375.2	11.7	11.64	11.38	679
.59	117.2		0.20		11.4	11.40		
11.07	116.1		0.1995		10.87	10.83?		
.07	116.7		0.4	750.4	23.7	23.?	22.56	1345
.11	116.3		0.403		22.3	22.1		
.14	116.8		0.40		22.8	22.8		
.26	115.2		7°.45'	1876	54.4?	54.7?	57.32	3418
—	116.2		—		59.1?	57.4?		
13.23	115.9		—		58.9?	57.1?		
.37	117.0		7°.50'		58.1	57.1		
.50	116.4		11°.15'	2814	80.1	82.6	81.83	4879
.57	119.3		11°.30'		80.4	81.0		
14.07	113.7		11°.20'		80.0	81.9		
.09	116.2		15°.30'	3722	105?	103.5?	102.93	6138
.16	116.2		15°.35'		104.8	102.7		
.18	115.5		15°.30'		104.8?	102.9?		
.32	115.5		18°.45'	4690	121.2	122.0	122.38	7297
.35	117.2		18°.55'		122	121.6		
.43	116.9		18°.25'		122.1?	122.3		
.50	115.9		22°.25'	5528	136	135.2	134.78	8036
.54	116.2		22°.30'		136.2?	134.9		
15.07	115.9		22°.30'		135?	134.3		
.14	115.9		28°.30'	7,506	148.2?	148.7?	149.93	8939
.22	115.9		28°.20'		148.2?	150.3		
.27	115.9		28°.30'		149.7?	150.8		
.33	116.3		34°.20'	9380	156.6	158.7	156.84	9352
.36	115.0		34°.20'		157.9	159.0		
.40	116.0		34°.35'		158.4?	158.8		
.47	116.0		39°.20'	11,256	161.?	161.1?	161.93	9655
.56	119.2		39°.25'		162.4?	162.0?		
.57	115.9		39°.30'		163.5?	162.7?		
16.01	115.2		43°.35'	13,132	167	167.9	170.07	10,141
.07	111.2		42°.25'		166.5?	172.3		
.11	113.2		42°.30'		166.9?	172.2		
.20	113.0		47°.35'	15008	171.2	178.8	173.33	10335
.23	115.8		47°.35'		170.3	170.2		
.29	112.0		46°.45'		169.	173.9		
.33	110.0		50°.30'	16984	173.4	175.9	176.97	10,552
.36	109.9		50°.15'		172.5	177.6		
.41	115.0		50°.50'		176.7	177.4		
.47	115.7		53°.35'	18760	177.1?	178.6	180.55	10,765
.54	113.2		53°.25'		177.2	179.8		
.57	112.1		52°.45'		177 ?	182.0		

1 Standard cell 0.5 f

21.5°C { 121.7, 121.5, 121.9, 122.0 } EMF 1.430

Mean 121.78

Mean temp. of room 21.9° C.

After observations.

21.5°C { 121.6, 121.8, 122.1, 122.0, 121.7 } EMF 1.431

Mean 121.84

$$\mathcal{L} = \frac{d \times 0.7153 \times 5264 \times 10^2}{121.81 \times 46.57} = 66.55\,d.$$

Time	Volts	Interpolar Ohms	Diet Ind. B	1.5 ohms Amperes	12.5 Thrust	Field Corrected	Adjusted Mean	$\mathcal{L}$
10.21	118.7		0.1005	187.6	6.9	6.866		
.28	119.8		0.101		5.7	5.644	5.905	398
.34	119.2		0.101		5.5	5.448		
.41	118.1		0.20	375.2	11.3	11.3		
.44	119.1		0.20		11.1	11.1	11.33	754
.50	117.2		0.1995		11.8?	11.83		
.55	117.3		0.399	750.4	23.07	23.06		
11.00	117.5		0.40		22.4	22.40	22.65	1507
.03	118.0		0.40		22.7	22.70		
.19	118.3		7°.45'	1876	59.4	59.66		
.22	117.5		7°.45'		59.4	59.46	59.62	3968
.26	117.2		7°.45'		59.6?	59.86		
.39	116.9		11°.20'	2.814	85.8	85.2		
.42	113.9		11°.25'		84.9	86.2	85.32	5678
.54	117.5		11°.25'		83.8?	83.8?		
12.17	117.2		15°.20'	3752	105.5	105.2		
.22	116.5		15°.15'		106.1?	105.3	105.9	7048
.29	116.3		15°.15'		106.0	106.4?		
.34	116.8		18°.50'	4690	121.2	121.4		
.42	116.9		18°.45'		121.4	121.3	121.6	8093
.46	117.1		18°.50'		121.1	122.0		
.54	117.0		22°.18'	5628	133.2?	133.2?		
.58	116.8		22°.20'		132.9?	132.7?	132.62	8824
13.25	116.8		22°.22'		133.1	132.3		
.31	117.0		25°.35'	7504	142.9	143.4		
.47	116.1		25°.35'		143.1	143.6	143.56	9554
.55	116.3		25°.35'		143.3?	143.3?		
15.00	115.9		34°.17'	9380	150.2	150.6		
.04	116.4		34°.15'		150.9	151.5	151.1	10056
.09	116.8		34°.15'		150.9?	151.3		
.21	116.8		39°.20'	11,256	157.8	157.9		
.26	115.8		39°.15'		156.2	156.8	156.87	10440
.31	117.8		39°.25'		158.3	155.9		
.36	115.9		43°.20'	13,132	161	163.3		
.42	116.2		43°.25'		162	163.8	163.12	10856
.45	115.6		43°.20'		162?	161.4		
.50	115.3		47°.20'	15008	165	164.4		
.57	116.3		47°.30'		164.4?	164.7	165.78	11,033
16.01	115.1		46°.45'		166.9?	169.6?		
.13	116.3		50°.10'	16,884	167.4?	171.8		
.17	116.0		50°.20'		168.1?	168.5	169.32	11,270
.27	116.5		50°.25'		168.5	168.5		
.33	115.9		54°.00	18,760	171.4?	170.2		
.39	116.7		53°.40'		171.2	170.4	171.56	11,418
.42	116.6		53°.45'		172	172.4		
	Diet.	between	poles	1.4.7 and 1.5	when when	current broken	10 amperes	

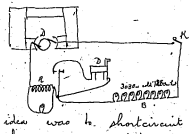
Physiological Experiments continued :— 14th July,

In the presence of Mr Brown + of Dr Peterson

Dr Peterson said that he had somewhat hastily examined under a microscope the ~~nerves~~ of sciatic + inferior cervical nerves of the legs of dogs 3 + 14 which took the current on the 12th inst: and that he found in the case of dog no 3 which had the direct current a considerable degree of pathological alteration in the medullary sheath which had become to a certain extent granulated resembling the morbid condition of nerve disease. The primitive membranes also were congested. In the case of the dog no 14, which had received the alternated current, this condition of the nerve was not evinced, but there was more pathological alteration and destruction of the nervous tissue generally than in the case of no. 3.

Dog # 5. Half bred shepherd specie. Weight 50lb. Height 23½ in. Length 39. Res: abt 6000.

Arranged connection as shewn:—



D Dynamo
K Key
B Bank of 8 lamps
R Relay shunted by 32cp lamp
D Dog.

The idea was to short circuit the dog by the relay lever as soon as it moved over after the delivery of a very short current, and thus and any

21.40 Volts 1000 0.10 ampères. Dog yelped once but not much hurt. Respirations immediately afterwards 120 per min.

21.44 Volts 1100 0.20 ampères. Dog yelped once but not much hurt. Resp: after 72.

21.46 Volts 1200 0.30 ampères. Dog yelped once but not much hurt. Resp: after shock 72.

21.51 Volts 1300 0.20 ampères Dog yelped once but not much hurt. Resp. after shock 60

21.53 Volts 1400 0.30 ampères Dog yelped once but not much hurt. Resp. 72.

21.57 Volts maximum 1420 0.20 amp. Dog yelped once but not much hurt. Resp. 72.

Res: of dog now taken again, and animal examined. He was much excited but otherwise uninjured. Res: about 6500.

It was now decided to give more than the above about current. It is obvious that the above potentials were based on the dog itself by at least $\frac{128000}{72.20} = 17\%$ and possibly as much as $\frac{30000}{9000} = 33\%$ owing to the interposition of the lamps in the circuit, and secondly the inductance of the armature diminishes the momentary current on first making contact.

Dog connected up again as before, bandages of copper wire on wet cotton waste on opposite leg to fore + hind leg. Resp: 152 per min.

22.30. 1200 volts 0.30 amp. 2½ secs: contact before releasing armature:

Dog yelped once but not much hurt.

Resp: 112.

Dog now released for examination.

The P.D. on the dog in this case must have been about 1000 and the calculated current 0.17 amp.

Dog #6 Black mongrel - Weight 55 lbs (80.)
Length 35"
Height 21".
Res: 3600.

alternating current 4100 turns per min
= 68·3 - - sec.

Resp. before application 1234 per min.
Lamp in multiple with dog acting as load
3.02 300 volts - alternating - contact 2 secs:- 0·1 amp.
Dog howled for about 1 min & struggled violently. Resp. 54 to 30 very variable.

22·21 400 volts alt. 2 secs.
Dog yelped and struggled. Resp. 168.

22·25 500 volts alt. 2 secs.
Dog yelped and struggled Resp. 170.

22·31 600 volts alt. 3 secs.
Dog yelped and groaned. Died in 90 secs.
Voltage fell during experiment being 540
one minute afterwards so that the true voltage at the time of delivery was probably alt. 570

Dog dissected by Dr Paterson.
Blood healthy. Muscles very irritable
Heart not beating but very irritable.
Much liquid dark venous blood.
Microscopic examination of blood did not indicate anything abnormal.
Part of sciatic nerves removed from each leg and from one fore leg.

To find the dimensions for a dynamo to supply v volts on the Faraday principle. Suppose the strength of field to be 5000 lines per sq. cm. Then if l be the length of the cylinder and r its radius then its circumferential speed at a known rev. of 1500 ft per min. is $\frac{1500 \times 30.48}{60 \times \cancel{\ldots}} = \frac{760}{\cancel{\ldots}}$

Consequently the area it will describe per sec. is $\frac{760 \pi l}{\cancel{\ldots}}$ and the voltage will be

$$v = \frac{5000 \times 760 \pi l}{\cancel{\ldots}} = \frac{3{,}760{,}000\, l}{\cancel{\ldots}} = v \times \cancel{\ldots}$$

$$\therefore \frac{l}{\cancel{\ldots}} = \cancel{\ldots} \; 26.6\, v.$$

The new Edison voltmeter exerts a pull of 0.75 grammes = 735 dynes when supplied with 1 ampere and has a range of about 3 volts on each side of 0 under those circumstances. When supplied with 0.75 amperes its pull is 0.28 grammes or 274.4 dynes. Its range is then fully 5 volts each side of the zero.

Monday 16th July

Took following observations of spring elasticity in the new Absolute Electrometer — Temp 33°C arbitrary. fiducial mark made of g.s. wire in beacons on bridge in absence of cover to read scale on top screw.

Instrument placed in hole slot and plane. The lower plate levelled, the upper plate brought parallel, and the moving plate adjusted to come to fiducial mark when in plane of upper guard plate.

	Reading		Difference
No weight		0810	
0·6 grammes		3330	2530
No weight		0804	
0·6 grammes		3370	2566
No weight		0804	
0·6 gr.		3316	2516
No weight		0805	
0·6 gr.		3375	2570
No weight		0805	
0·6 gr.		3365	2560
No weight		0805	
0·6 gr.		3372	2567
		Mean	2552

When cover in its place the zero reading is 0795 so that the selected reading is to be 3347. say 1335. This corresponds to the pull of 06 grammes weight. This weight was distributed fairly in ~~det~~ grammes weights over the surface of the plate.

1 Standard cell Temp. 20.3°C. through 0.5t

122
122.6
122.3 ?
122.7 ?

EMF 1.4322

Mean 122.37

Mean temp: of room 23.15°C.

After observation

122
121.2 ?

T. 23.62. 121.5
121.3
121.9

EMF 1.4284

Mean 121.62

$$L = \frac{d \times 0.71515 \times 5288 \times 10^{-}}{121.995 \times 46.57} = 66.5624$$

Interpolar dist. 1. 4m. 12.5 Indy BR

Time	Volts	Ohm	Ind. B.	Amperes	Shunt	Corrected	Adjusted	B
7.42	115.9		0.1005	187.6	7.3	7.26	7.42	492
.44	115.2		0.1		7.2	7.2		
.53	116.9		0.1		7.2	7.2		
8.17	115		0.2	375.2	14.2 ?	14.2 ?	14.140	959
0.13	115.8		0.2		14.8	14.8		
.27	116		0.2		14.1	14.1		
.17	116		0.4	750.4	28.8	28.8	28.43	1892
.22	115.8		0.399		28.1	28.17		
.35	115.6		0.397		28.1	28.31		
.37	116.5		7°.40'	1876	74	73.68	73.8	4912
.46	116.2		7°.40'		73.7	73.38		
.56	115.5		7°.40'		73.2	72.83		
11.39	115.9		11°.35'	2814	101.7	101.7	102.3	6809
.42	117		11°.35'		102.3	102.3		
.46	115.0		11°.35'		103.0	103.0		
.53	118.0		15°.15'	3752	126.3	125.6	126.9	8447
.57	113.		15°.00		125	124.5		
12.20	117.3		15°.10'		125.7	125.5		
13.22	118.2		18°.50'	4690	140.7	140.14	140.58	9358
.26	118.2		18°.50'		140.6	140.9		
.27	117.3		18°.50'		140.0 ?	140.3 ?		
.32	117.0		22°.20'	5528	114.9 ?	118.7 ?	119.0	9915
.42	117.		22°.20'		115.8 ?	118.8 ?		
.50	117.2		22°.20'		159.1 ?	119.8 ?		
.55	117.0		25°.40'	7502	160.3 ?	160.3 ?	159.9	10,644
14.00	117.6		28°.35'		159.4 ?	160.0		
.03	116.5		28°.35'		158.9	159.5		
.14	117.		34°.20'	9380	167.7 ?	167.8 ?	166.78	11,101
.13	117.		34°.20'		167.0 ?	167.1		
.23	117.2		34°.20'		166.4	166.2		
.28	117.		39°. 05'	11,256	171.2	172.9	172.68	11491
.36	116.1		39°. 15'		171.9	172.5		
.40	116.9		39°. 10'		171.3	172.5		
.48	115.9		43°.35'	13,132	175.6	176.6	176.44	11,742
.52	115.7		43°.35'		176.0	177.0		
.56	117.6		43°.50'		176.1	176.5		
15.01	113.8		47°.30'	15,008	179.5 ?	179.9 ?	180.18	11,994
.07	116.5		47°.30'		179.2 ?	179.6 ?		
.10	115.3		47°.25'		180.3	181.2		
.20	114.0		50°.40'	16,814	182.9	184.14	183.2	12,195
.24	114.5		50°.40'		181.2	182.7		
.30	115.5		50°.00		183.1	182.4		
.34	115.8		53°.55'	18,760	185.8 ?	185.0	186.7	12,427
.38	114.7		53°.40'		186.9 ?	187.9		
.43	116.6		53°.35'		185.4	187.0		

Interpolar dist. at last current 0.965 after breaking

cut 1.0

Tuesday 17th July.

Took out zinc plates from the primary battery and weighed them as follows.

Cell No.	Plate No.	Weight 9.7.88 oz.	Weight 17.7.88 oz.	Loss oz.	Weight 9.7.88 grs.	Weight 17.7.88 grs.	Loss grs.	Cell Loss grs.
1	1	56·13	45·75	10·38	1592	1297	295	
	2	53·75	42·75	10·00	1524	1212	312	607
				20·38				
				578 g.				
2	1							
	2	56·25	43·50	12·75	1595	1233	362	362
3	1	58·20	47·75	10·45	1650	1354	296	
	2	54·25	42·75	11·50	1538	1212	326	622
				21·95				
				622 g.				
4	1	82·0	69·5	12·5	2325	1970	355	
	2	83·5	76·75	6·75	2367	2176	191	546
				19·25				
				546 g.				
5	1	82·25	73·	9·25	2332	2070	262	
	2	77·75	68·5	9·25	2204	1942	262	524
				18·5				
				524 g.				
6	1	81·5	68·0	13·5	2311	1928	383	
	2	82·6	77·75	4·85	2342	2204	138	521
				18·35				
				520 g.				

The Roberts-Austen cell has zinc 6" × 13" 33 × 1524 Liquid rise 4 1/2" 30·5 cm.

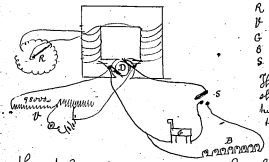
The Moore Wood cell has zinc 6" × 13" 33 × 1524 Liquid rise to 9" 22 cm.

The 5 volt dynamo charged from the 130 volt circuit gives 5.1 volts @ 1676 revs. per min.

The first 4 Barrett Apple give EMFs applied at 23°c.

No 1.	1.026	volts
" 2	1.030	"
" 3	1.031	"
" 4	1.031	"

Physiological Experiments continued :—



D. Dynamo
R Field Resistance
V Voltmeter connection
G Dog
B Lampbank 12 lamps
S switch.

The arrangement shown that in turning the switch towards the right contact is first made through the dog and subsequently through both dog and lampbank which finally the lamps only are left in circuit so that when the circuit is completed broken any discharge from the inductance of the armature will have passed through the lamps and not through the dog.

Mr Brown not present at this experiment.

A foucault interrupter beating 62 times to the minute was used to give time for contact

Dog #7 Yellow mongrel.
Length tip of nose to base of tail 28½"
Height at shoulder 18"
Weight 35 lbs.

Res: between usual bandages on legs 20,000ω.

22.15 Direct current applied to dog between right fore and left hind legs: 500 volts EMF current observed 0.025 ampere.
Calculated value $\frac{500}{20,000} = 0.025$ also.
duration of contact at switch S = 4 secs.
The dog yelped once while current on, and howled afterwards, but died within a minute.

22.22 Carcass thrown into furnace.

23.00 Only a handful of calcined bones left of carcass.

Dog #8. Bull terrier
Length tip of nose to base of tail 46"
Height 23"
Weight 47 lbs.

Desired to find the effect of a comparatively low EMF passing through the head. For this purpose put two pads of wet cotton wool enclosing wire into the cavities of the ears, bandaging down the external ears over them with a strip fairly tight so as to keep the connection steady. The res: between the electrodes so formed was 6,900ω.

22.55. Direct current passed through head between ears for 4 secs: at 300 volts pressure by switch S. observed current 0.03 amp calculated out $\frac{300}{10,000} = 0.03$ amp

The dog was standing up in a box with his head over the side. While the current was passing there was no struggling or yelping, and beyond the half closing of the eyes and a trembling of the head it would be difficult to see the effect of the current. After removing the current however, the back of the dog arched rigidly as though in a spasm of tetanus, ~~but~~ the animal which it seemed dazed was ~~quite~~ apparently quite conscious. The rigidity continued. He did not struggle violently to escape but looked just as though suffering from strychnine.

Tried next the same voltage only alternated at the high speed (68 per sec)

23.00 300 volt pressure – alternating current through head – for 4 seconds.

A before while the current was on there was little indication of its effect, but on the cessation of the current the effect was ~~most~~ intense. The eyes suffused with blood – and secreted rapidly, the head swayed from side to side, the animal still ~~stood~~ upright but did so with apparent difficulty as the limbs contracted violently. The breathing was spasmodic and laboured, and foam issued at the mouth. The animal had the appearance of mania and may have been unconscious for the first minute (but seemed to slowly regather consciousness) while in the appearance of great pain. Hastened to apply the whole power of the

machine in order to terminate his suffering. Bandaged the legs, as the ear bandages were now discarded. The dog seemed incapable of howling during the whole experiment. At 23.12 attempted at full speed. (68 per sec) the whole power of the machine as heavy collection 1200 volts, and made contact for 4 secs: amperes over 1.2. The animal struggled silently for a few moments and within 15 secs fell back dead. Carcass examined.

Unable to get absolute electrometer to hold its charge. Took it apart and dried it all thoroughly. In resetting it took several more measurements of the elastic force of the spring as follows.

No.	weight.			Diff
	1.680	0.6 gr.	4.255	2.575
	1.688	0.6	4.255	2.567
	1.692	0.6	4.262	2.570
	1.700	0.6	4.260	2.560
				Mean 2.568
	1.695	0.3 gr	3.015	1.320
	1.710	0.3	3.042	1.332
	1.690	0.3	3.021	1.331
				Mean 1.328

Temp 75°F

Brevoort Roberts Cell no 1 first trial

Hours	C.	Coulomb	C²	External Joules	S.R.	Internal Joules	
5	4·04		16·3		0·0175		
10	4·01		16·1		0·0152		
15	3·98		15·8		0·0177		
20	3·92		15·4		0·0222		
25	3·88		15·1		0·0225		
30	3·87		15·0		0·0239		
35	3·87		15·0		0·0240		
40	3·85		14·8		0·0306		
45	3·82		14·6		0·0352		
50	3·80		14·4		0·0402		
55	3·78		14·3		0·0450		
60	3·77		14·2		0·0485		
65	3·78		14·3		0·0479		
70	3·80		14·44		0·0453		
75	3·74		14·0		0·0105		
80	3·41		11·6		0·0300		
85	3·10		9·61		0·0510		
90	2·78		7·73		0·0750		
95	2·48		6·15		0·0940		
100	2·18		4·75		0·1045		
105	1·89		3·57		0·1058		
110	1·62		2·62		0·1067		
115	1·36		1·85		0·1070		
120	1·09		1·18		0·1077		
125	0·94		0·88		0·1030		
130	0·93		0·86		0·1040		
135	0·91		0·82		0·1047		
140	0·90		0·74		0·1041		
145	0·81		0·66		0·1030		
150	0·80		0·64		0·0989		
155	0·78		0·61		0·0953		
160	0·77		0·60		0·0970		
165	0·77		0·59		0·0998		
	85·43	1,538,000	279·16	2,512,000		177,400	2,690,000

Theoretical amp: 519 gm Zn.
Actual loss 1303
Waste 785 or 60·4 %

Percentage useful energy = 93.38 %

Brevoort-Roberts Cell no 2 first trial.

Hours	C.	Coulomb	C²	External Joules	S.R.	Internal Joules	
5	3·51		12·3		0·0715		
10	3·48		12·1		0·0642		
15	3·45		11·9		0·0665		
20	3·42		11·7		0·0724		
25	3·38		11·4		0·0788		
30	3·29		10·8		0·0925		
35	3·21		10·3		0·1130		
40	3·19		10·2		0·0985		
45	3·16		10·0		0·0940		
50	3·16		9·98		0·0897		
55	3·16		9·86		0·0852		
60	3·08		9·49		0·0845		
65	3·00		9·00		0·0875		
70	2·92		8·53		0·0909		
75	2·83		8·01		0·0927		
80	2·67		7·13		0·0887		
85	2·50		6·25		0·0844		
90	2·33		5·43		0·0801		
95	2·16		4·67		0·0759		
100	1·91		3·65		0·0734		
105	1·57		2·46		0·0728		
110	1·36		1·85		0·0745		
115	1·22		1·49		0·0775		
120	1·08		1·17		0·0813		
125	1·06		1·12		0·0750		
130	0·99		·98		0·0540		
135	0·92		·85		0·0536		
140	0·88		·77		0·0587		
145	0·85		·73		0·0615		
150	0·85		·72		0·0578		
155	0·84		·70		0·0556		
160	0·83		·69		0·0625		
165	0·81		·66		0·0705		
	73·07	1,315,000	194·69	1,772,000		293,000	2,065,000

Theoretical amp: 444 gm Zn.
Actual 516
Waste 73 = 14.15 %

% Useful work = 85.79 %

Robert Brewoort cells no 3 1st trial

	B	Bookings	B²	Book Index				
5	3.56		12.7			0.0850		
10	3.52		12.4			0.0688		
15	3.49		12.2			0.0711		
20	3.46		12.0			0.07400		
25	3.44		11.8			0.07762		
30	3.43		11.8			0.0752		
35	3.42		11.7			0.07400		
40	3.37		11.4			0.0761		
45	3.33		11.1			0.0788		
50	3.28		10.8			0.0813		
55	3.22		10.4			0.0839		
60	3.15		9.92			0.0887		
65	3.07		9.06			0.0965		
70	2.90		8.39			0.1047		
75	2.76		7.61			0.1092		
80	2.55		6.50			0.1047		
85	2.34		5.47			0.0947		
90	2.11		4.58			0.0945		
95	1.92		3.76			0.0892		
100	1.71		2.92			0.0867		
105	1.46		2.13			0.0973		
110	1.27		1.61			0.0890		
115	1.12		1.25			0.0910		
120	0.98		0.96			0.0928		
125	0.84		0.88			0.0735		
130	0.89		0.79			0.0751		
135	0.86		0.74			0.0672		
140	0.84		0.71			0.0588		
145	0.81		0.66			0.0555		
150	0.81		0.65			0.0772		
155	0.80		0.64			0.0750		
160	0.79		0.63			0.0697		
165	0.78		0.62			0.0790		
170								
	72.57	1,303,000	194.77	1,749,000		292.500		2,090,600

Theoretical 100 1439 gm.
Actual - 516 -
Waste - 77 = 14.92 %

Percentage useful energy = 86.01 %

Robert Brewoort Cell no 1. 2nd trial

	B	Bookings	B²	Book Index				
5	3.5		12.25	110300		0.100		22060
10	3.48		12.11	109000		0.091		19840
15	3.5		12.25	110300		0.082		18090
20	3.52		12.39	111200		0.074		16460
25	3.55		12.60	113400		0.069		15650
30	3.56		12.67	114000		0.065		14820
35	3.55		12.60	113400		0.066		14960
40	3.52		12.53	112800		0.067		15110
45	3.53		12.46	112200		0.067		15030
50	3.48		12.76	109000		0.069		15040
55	3.43		11.76	105800		0.071		15020
60	3.42		11.69	105200		0.070		14730
65	3.43		11.76	105800		0.067		14186
70	3.44		11.83	106500		0.067		14270
75	3.40		11.56	103800		0.071		14740
80	3.36		11.29	101600		0.074		15040
85	3.28		10.76	96800		0.077		14910
90	3.20		10.24	92100		0.079		12550
95	3.11		9.67	87000		0.081		14090
100	3.00		9.00	81000		0.081		13120
105	2.87		8.24	74200		0.081		12020
110	2.69		7.23	65100		0.081		10550
115	2.51		6.30	56400		0.080		9020
120	2.29		5.24	47200		0.078		7360
125	1.93		3.72	33500		0.075		5020
130	1.76		3.10	27900		0.074		4130
135	1.64		2.69	24200		0.073		3530
140	1.52		2.31	20800		0.072		3000
145	1.49		2.22	20000		0.071		2840
150	1.26		1.59	14300		0.070		2000
155	1.14		1.30	11700		0.069		1610
160	1.01		1.02	9200		0.068		1250
165	.88		.77	6900		0.067		920
170	.72		.52	4700		0.067		630
	91.99	1,656,000	219.78	2,818,000			3785.90	2,893,600

Theoretical 557.59
Actual 607
Waste 49.5
or ~~27.7~~ % total loss.
8.16%

97% total energy.

Percentage useful energy = 87.02 %

Robert Brevoort Cell no 3 2nd trial.

	E.	Coulombs	E.	Get. Joules	Int. Res.	Int. Joules	
5	3.4		11.56	104,100	0.110	25,1000	
10	3.41		11.63	104,700	0.101	211,600	
15	3.45		11.90	107,100	0.093	199,200	
20	3.48		12.11	109,000	0.083	180,900	
25	3.50		12.25	110,300	0.080	176,900	
30	3.52		12.39	111,500	0.078	173,900	
35	3.52		12.39	111,500	0.077	171,700	
40	3.52		12.39	111,500	0.076	169,500	
45	3.51		12.32	110,900	0.076	168,600	
50	3.50		12.25	110,200	0.075	165,300	
55	3.42		11.70	105,300	0.073	153,700	
60	3.42		11.70	105,300	0.074	155,800	
65	3.43		11.76	105,900	0.076	161,000	
70	3.41		11.63	102,700	0.078	163,300	
75	3.39		11.42	102,800	0.083	129,500	
80	3.33		11.09	99,800	0.052	103,800	
85	3.25		10.56	95,000	0.064	121,600	
90	3.17		10.05	90,400	0.079	142,80	
95	3.08		9.49	85,400	0.089	152,000	
100	2.98		8.88	79,900	0.090	141,300	
105	2.86		8.18	73,800	0.090	132,500	
110	2.67		7.13	64,200	0.089	114,300	
115	2.48		6.15	55,400	0.088	97,50	
120	2.23		4.97	44,700	0.087	77,0	
125	1.85		3.42	30,800	0.087	53,60	
130	1.71		2.92	26,300	0.087	45,80	
135	1.60		2.56	23,000	0.087	40,00	
140	1.47		2.16	19,400	0.087	33,80	
145	1.44		1.82	16,400	0.087	28,50	
150	1.23		1.51	13,600	0.087	23,70	
155	1.11		1.23	11,100	0.087	19,30	
160	0.99		0.98	8,800	0.087	15,30	
165	0.87		0.76	6,800	0.087	11,80	
170	0.79		0.62	5,600	0.086	9,60	
	90.98	103,000	273.68	246,500		599,980	2,865,000

Theoretical Z 551 86%

Actual 622

Waste 71 or 11.4% of total loss

Percentage useful Work = 86.04

Mason Wood Cell no 1.

	E.	Coulombs	E.	Get. Joules	Int. Res.	Int. Joules	
5	3.38		11.42	102,800	0.095	19,530	
10	3.14		9.86	88,800	0.107	20,780	
15	2.84		8.06	72,600	0.125	18,150	
20	2.50		6.25	56,300	0.144	16,210	
25	2.10		4.41	39,700	0.173	13,740	
30	1.62		2.62	23,600	0.204	9,630	
35	1.33		1.77	15,900	0.245	7,790	
40	1.06		1.12	10,100	0.287	5,800	
45	0.82		0.67	6,000	0.320	3,840	
50	0.76		0.58	5,200	0.215	2,240	
55	0.72		0.52	4,700	0.100	940	
60	0.70		0.49	4,400	0.167	1,470	
65	0.69		0.48	4,300	0.275	2,360	
70	0.67		0.45	4,100	0.390	3,200	
75	0.65		0.42	3,800	0.427	3,240	
80	0.64		0.41	3,700	0.439	3,240	
85	0.62		0.38	3,400	0.436	2,960	
90	0.61		0.37	3,300	0.433	2,860	
95	0.59		0.35	3,200	0.437	2,800	
100	0.58		0.34	3,100	0.450	2,800	
105	0.58		0.34	3,100	0.468	2,900	
110	0.57		0.32	2,900	0.485	2,900	
115	0.57		0.32	2,900	0.500	2,900	
120	0.56		0.31	2,800	0.500	2,800	
125	0.56		0.31	2,800	0.476	2,660	
130	0.55		0.30	2,700	0.485	2,620	
135	0.55		0.30	2,700	0.499	2,690	
140	0.54		0.29	2,600	0.507	2,640	
145	0.53		0.28	2,500	0.525	2,620	
150	0.52		0.27	2,400	0.540	2,590	
155	0.52		0.27	2,400	0.554	2,490	
160	0.51		0.26	2,300	0.566	2,720	
165	0.50		0.25	2,200	0.578	2,660	
170	0.50		0.25	2,200	0.561	2,480	
	35.59	400,400	58.01	49,500		181,150	576,500

Theoretical Z 203.5

Actual 526. Waste 322.5 or 62.73% total loss. Percentage useful Work = 71.23

Mason - Wood cell no 2.

Hours	C.	Coulomb	C²	Ext. foots	Int. H.	Int. foots	
.5	3.40		11.56	104,000	0.072	14,980	
10	3.26		10.62	95,600	0.089	17,020	
15	3.12		9.73	87,600	0.108	18,570	
20	3.00		9.00	81,000	0.122	17,760	
25	2.98		8.88	79,900	0.127	22,280	
30	2.85		8.12	73,100	0.150	19,000	
35	2.42		5.85	52,700	0.147	15,490	
40	1.95		3.80	34,200	0.167	11,420	
45	1.48		2.19	19,700	0.180	7,090	
50	1.18		1.39	12,500	0.145	3,910	
55	0.92		0.85	7,700	0.110	1,890	
60	0.85		0.72	6,500	0.160	2,080	
65	0.80		0.64	5,800	0.230	2,700	
70	0.74		0.55	5,000	0.313	3,130	
75	0.71		0.50	4,500	0.324	2,920	
80	0.69		0.48	4,300	0.332	2,850	
85	0.67		0.45	4,100	0.336	2,760	
90	0.65		0.42	3,800	0.343	2,600	
95	0.63		0.39	3,500	0.348	2,440	
100	0.61		0.37	3,300	0.360	2,370	
105	0.60		0.36	3,200	0.370	2,360	
110	0.60		0.35	3,200	0.380	2,430	
115	0.59		0.35	3,200	0.392	2,500	
120	0.58		0.34	3,100	0.395	2,440	
125	0.58		0.34	3,100	0.384	2,380	
130	0.57		0.32	2,900	0.383	2,220	
135	0.57		0.32	2,900	0.385	2,230	
140	0.55		0.31	2,800	0.389	2,180	
145	0.56		0.31	2,800	0.392	2,200	
150	0.55		0.30	2,700	0.395	2,130	
155	0.54		0.29	2,600	0.397	2,060	
160	0.54		0.29	2,600	0.400	2,080	
165	0.54		0.29	2,600	0.403	2,090	
170	0.53		0.28	2,600	0.409	2,120	
	40.82	734,500	80.96	730,000		52,480	932,500

Theoretical In heat watts 247.4 gro 526 = 276.6 = 52.79%

Percentage useful Work = 71.28%

Mason - Wood Cell no 2.

Hours	C.	Coulomb	C²	Ext. foots	Int. H.	Int. foots	
5	3.27		10.69	96,200	0.132	25,200	
10	3.26		10.50	94,500	0.123	23,200	
15	3.18		10.11	91,000	0.116	21,100	
20	3.12		9.73	87,600	0.108	18,900	
25	2.98		8.88	79,900	0.117	18,700	
30	2.79		7.78	70,000	0.130	18,200	
35	2.35		5.52	49,700	0.218	21,400	
40	1.87		3.50	31,500	0.300	18,900	
45	1.38		1.90	17,100	0.375	12,800	
50	1.10		1.21	10,900	0.320	7,000	
55	0.86		0.74	6,700	0.240	2,200	
60	0.77		0.59	5,300	0.270	1,900	
65	0.72		0.52	4,700	0.323	3,100	
70	0.68		0.46	4,100	0.410	3,400	
75	0.65		0.42	3,800	0.424	3,200	
80	0.63		0.40	3,600	0.433	3,000	
85	0.61		0.37	3,300	0.435	2,900	
90	0.60		0.36	3,200	0.437	2,800	
95	0.59		0.35	3,200	0.442	2,800	
100	0.58		0.34	3,100	0.456	2,800	
105	0.56		0.31	2,800	0.471	2,600	
110	0.56		0.31	2,800	0.487	2,700	
115	0.56		0.31	2,800	0.500	2,800	
120	0.56		0.31	2,800	0.517	2,900	
125	0.56		0.31	2,800	0.525	2,900	
130	0.56		0.31	2,800	0.527	2,900	
135	0.55		0.30	2,700	0.544	2,900	
140	0.54		0.29	2,600	0.561	2,900	
145	0.53		0.28	2,500	0.580	2,900	
150	0.52		0.27	2,400	0.599	2,900	
155	0.52		0.27	2,400	0.612	2,900	
160	0.51		0.26	2,300	0.622	2,900	
165	0.50		0.25	2,300	0.630	2,900	
170	0.50		0.25	2,300	0.624	2,900	
	39.50	711,000	78.40	705,700		237,900	963,400

Theoretical 239 kgm
Actual 521
waste 281.6 = 54.01%

Percentage useful Work = 73.26.